NBN Sinhgad Technical Institute Campus

NBN Sinhgad School of Engineering, Ambegaon, Pune

DEPARTMENT OF COMPUTER ENGINEERING

210260: Audit Course II

WATER MANAGEMENT

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CERTIFICATE

This is to certify that,

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Of Class SE2 *Roll No.* S5559 *has completed all the report on* ***"WATER MANAGEMENT"*** *of subject* ***Audit Course II*** *Satisfactorily in the Department of* ________________ *as prescribed by the Savitribai Phule Pune University, Pune in the, academic year 2022- 2023*

Remark:

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INTRODUCTION

1.1 Concepts

Soil, vegetation and water are the most important and vital natural resources for the survival of man and his animals. To obtain the optimum production of biomass, all the three natural resources have to be managed efficiently and one has to look for a suitable "Units(s) of management" so that their resources are managed effectively, collectively and simultaneously. Soils can be managed on the basis of a soil series or type or any other convenient unit of land; vegetation can be managed on forest type/forest sub- type or similar classification for trees/grasses etc. Water can be managed if a watershed is taken as a unit. Since soil and vegetation can also be conveniently and efficiently managed in this unit, the watershed is considered the ideal unit for managing these three vital and interdependent natural resources of soil, water and vegetation.

1.2 Definition

Watershed is that area from which all precipitation flows to a single stream. Synonyms are "catchment area" and "drainage basin". The boundaries of watershed are known as drainage divide; precipitation falling on opposite sides of a drainage divide falls into different watershed. Only part of the precipitation that falls on a watershed ultimately gets into the stream; it is known as runoff and varies widely among watersheds. The rest of the precipitation either evaporates back into the atmosphere directly from the water surface or from land surface. The part of the precipitation that is intercepted by vegetation is also evaporated and returned to the air. Out of the water absorbed by the plants from the soil, a substantial portion is also returned to the atmosphere by transpiration. Other simple definition of watershed can be "a unit of area which covers all land and water areas which contribute runoff to a common point". A watershed may be only a few hectares as in case of small ponds or hundreds of square kilometres as in case of rivers. All watersheds can be divided into smaller sub-watersheds. Watershed management is done to achieve various objectives.

1.3 Objectives

The main objective of watershed management is the "proper use of all the available resources of a watershed for optimizing productivity with minimum hazards to natural resources". The other objectives of watershed management programmes are:

- ·Recognition of watersheds as a unit for development and efficient use of land according to their land capabilities for production without any environmental degradation;

- ·Conservation, development and sustainable management of natural resources including their use;
- ·Conserve as much rainwater as possible in the places where it falls, of course without disturbing the natural hydrological system, increasing the groundwater level and maintaining it for sustainable use;
- ·Prevent soil erosion and reduce sediment production by means of suitable soil and water conservation measures;
- ·Enhancement of agricultural productivity and production in a sustainable manner;
- ·Restoration of ecological balance in the degraded and fragile rainfed ecosystems by greening these areas through appropriate mix of vegetation, viz., trees, shrubs and grasses;
- ·Reduction in regional disparity between irrigated and rainfed areas;
- ·Improve infrastructural facilities in the watershed;
- ·Provide training and build capacity of the primary stakeholders through participatory approaches so as to evolve a demand driven action plan for sustainable Water Management;
- ·Creation of sustained employment opportunities for the rural community including the landless; and
- ·Evolve monitoring and evaluation methods to make the programme transparent, flexible and cost effective. Community based organizations and the people shall be partner in this endeavour.

Enhancement of productivity through the farming systems perspective; farmers participatory approach is the key to the success and that would raise the productivity level of rainfed areas of India. Addressing only a component of the farming systems, e.g., crop variety, fertilizer use and even crop husbandry per hectare does not generally result in dramatic increase in productivity as witnessed in irrigated areas. The farming systems perspective therefore, can be the proper management strategy for such regions.

The factors which affect the watershed behaviour and which need to be studied in management Programmes are (i) size and shape of the watershed (ii) topography (iii) soil and their characteristics, (iv) precipitation (v) land use and (vi) vegetative cover. Data to be collected for planning of watershed programmes are (i) hydrological information precipitation, climate data, flow data and sediment flow, (ii) soil and land use data, soil data, topography, geology and vegetation and (iii) socio-economic data as per needs of the people to work out cost benefit of the project

1.4 Importance

Runoff from rainwater or snowmelt can contribute significant amounts of pollution into the lake or river. Watershed management helps to control pollution of the water and other natural resources in the watershed by identifying the different kinds of pollution present in the watershed and how those pollutants are transported, and recommending ways to reduce or eliminate those pollution sources.

All activities that occur within a watershed will somehow affect that watershed's natural resources and water quality. New land development, runoff from already-developed areas, agricultural activities, and household activities such as gardening/lawn care, septic system use/maintenance, water diversion and car maintenance all can affect the quality of the resources within a watershed. Watershed management planning comprehensively identifies those activities that affect the health of the watershed and makes recommendations to properly address them so that adverse impacts from pollution are reduced.

Watershed management is also important because the planning process results in a partnership among all affected parties in the watershed. That partnership is essential to the successful management of the land and water resources in the watershed since all partners have a stake in the health of the watershed. It is also an efficient way to prioritize the implementation of watershed management plans in times when resources may be limited.

Because watershed boundaries do not coincide with political boundaries, the actions of adjacent municipalities upstream can have as much of an impact on the downstream municipality's land and water resources as those actions carried out locally. Impacts from upstream sources can sometimes undermine the efforts of downstream municipalities to control pollution. Comprehensive planning for the resources within the entire watershed, with participation and commitment from all municipalities in the watershed, is critical to protecting the health of the watershed's resources.

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LOOSE BOULDER BUND

A Loose boulder bund is a small barrier constructed of rock, gravel bags, sandbags, fibre rolls, or reusable products, placed across a constructed swale or drainage ditch. These check dams reduce the effective slope of the channel, thereby reducing the velocity of flowing water, allowing sediment to settle and reducing erosion and can provide a 'drought-proof' water supply (from groundwater). Groundwater recharge collects water during wet season for use in dry season, when demand is high.

If loose stones of fairly good size are available in large quantities, they can be used for construction of check dams. The site where the check dam is to be constructed is cleared. The bed of the gully is excavated to a uniform depth of about 0.3 m and dry stones are packed from that level.

In the centre of the check dam, sufficient weir size for water-way is provided to discharge the peak runoff from the catchment. The stone filling should go up to 0.3 - 0.6 m into the stable portion of the gully side to prevent end cutting. In the rear, sufficient length and width of apron has to be provided to prevent scour. The thickness of the apron packing should not be less than 0.15 m and the gully sides above the apron have to be protected with stone pitching to a height of at least 0.3 m above the anticipated maximum water level to prevent side scours from being formed by the falling water. Care should be taken to place bigger sized stones on top to prevent the pitching being dislodged or carried away by the current.

Temporary check dams are specially adapted to gullies with small watersheds. They should be extended far enough into the bottom and sides of the gully to prevent wash outs underneath or around the ends. Sufficient spillway capacity must be provided in the structure. Low dams are less likely to fail and better after silt up and rot away. The vegetation can protect low over fall height of a temporary check dam which should not ordinarily be more than 1 meter and preferably 75 cm. With greater heights, the static pressure increases. , tending to force leaks underneath the structure. Overall scour is also difficult to control.

2.1 Suitability

These are generally constructed at upper reaches of drainage lines/gullies in the newly formed or branches of main nallas less than 100 m in length, where plenty of boulder stones are locally available.

2.2 Design Specifications

Dry stone/ loose boulder check dams are usually constructed up to about 1.25 m height and about 2.5 m length. The foundation of the check dams should be dug out from 0.3 m - 0.5

m and the keying into stable portion of banks is also kept from 0.3 m - 0.6 m. Top width of the check dam is kept from 0.5m with the sides sloping at 0.5 H: 1 V.

Following design criteria of dry stone masonry structure has been in practice and has been found to be suitable for adoption:

i. The maximum height of structure should not be more than 1.0 m

ii. Base width = 1.4 Height

iii. Top width = 0.4 Height

iv. Depth of foundation = 0.4 Height

v. Downstream slope = 1:1

vi. Earth backing on the upstream vertical face of the wall is provided at a slope of 4:1 or 5:1 depending on the soil type & the bottom width of earth backing be kept so that the seepage line remains within the earth backing.

vii To strengthen the structure cement concrete (1:2:4) of 0.10 m on top & plaster with cement mortar (1:4) , 25 mm thick may be taken on sides.

2.3 Investigations

i. L-section and cross section survey plan at suitable interval of the nallas in which such structures are proposed to be constructed.

ii. The rainfall data of last 10 years.

iii. Type of soil of the catchment.

2.4 Spacing between check dams

Since the purpose of check dams in gully control is to reduce or eliminate grade in the channel, check dams should be spaced such that the crest elevation of one at downstream will be the same as the bottom elevation of the adjacent check dam at upstream. However, in practice a small grade is usually allowed in the gully bed to reduce the number of checks. A grade of 0.1 percent is usually allowed in fine sand and silt loam soils and up to about 0.5 per cent in silt and clay soils.

The spacing of each check dam across the nallah can also be calculated with the help of the following formula:

Spacing- $H \div (KGCos\alpha)$

Where,

H = crest height in meters

α= Natural grade of nallas bed in degrees

G = tan α

K = Constant 0.3 when G < 0.2; and 0.5 when G > 0.2

2.5 Overall protection

As an integral part of most check dams, an apron or platform of sufficient length and width must be provided to dissipate the kinetic energy of the water falling without scour. Brush and loose rock are generally used to provide overall protection.

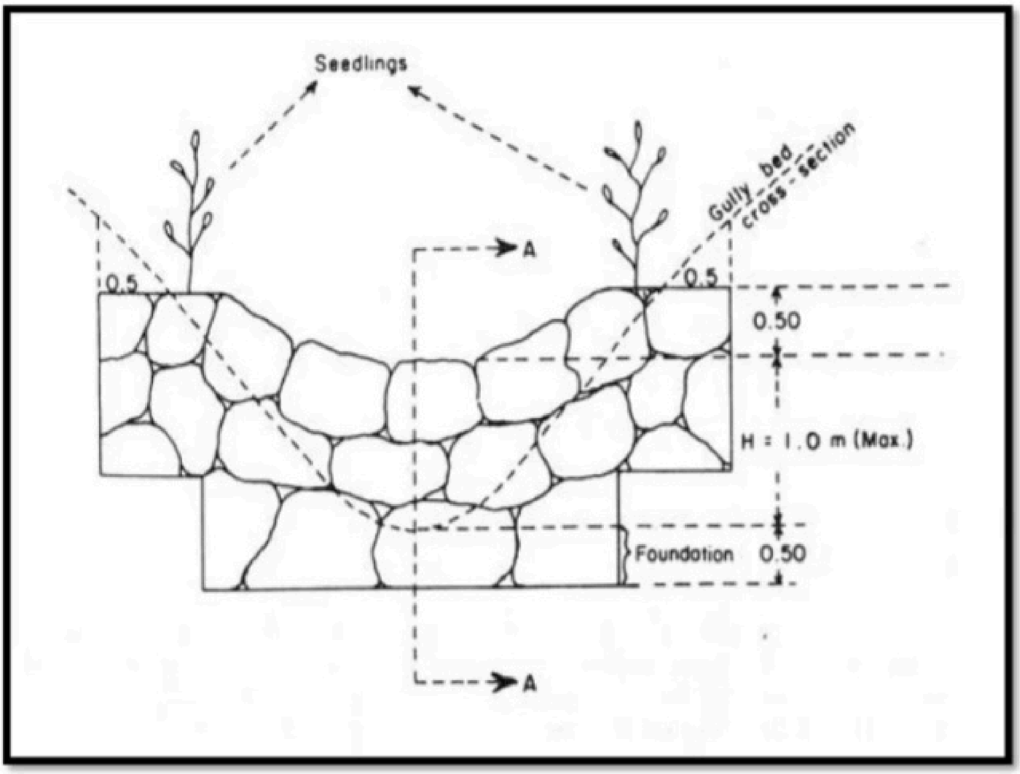


Fig. 1 Typical Cross-Section of Loose Boulder Check Dam

Fig. 2 Loose Boulder Check Dam

SUNKEN POND

It is dug cum embankment type ponds constructed in the narrow valley portion of stream or nallas particularly at the site, which has already depressions. These ponds are being widely constructed for storing rainwater for the purpose of livestock drinking and ground water recharge.

These ponds act as miniature storage points within the channel recharging ground water at every point in the village.

Small boulders excavated during earth work are assembled on upper edge of the sunken pond so as to scale down the water's velocity, prevent soil erosion and accumulation of silt in the main tanks.

Two-foot wide, two-foot long and one-foot deep ponds are dug at various points in the supply channels, mostly laid along rural roads or along agricultural fields, It acts as temporary water source for cattle and goats near the feeding area.

As this method, has improved the water holding capacity, sunken ponds will be dug in the inlet and outlet of rivers and in all the supply channels in 14 blocks, it was said.

GABION STRUCTURE

A gabion wall is a retaining wall made of stacked stone-filled gabions tied together with wire. Gabion walls are usually battered (angled back towards the slope), or stepped back with the slope, rather than stacked vertically. The most common Computer Engineering use of gabions was refined and patented by Gaetano Maccaferri in the late 1800s in Sacerno, Emilia Romagna and used to stabilize shorelines, stream banks or slopes against erosion. Other uses include retaining walls, noise barriers, and temporary flood walls, silt filtration from runoff, for small or temporary/permanent dams, river training, or channel lining. They may be used to direct the force of a flow of flood water around a vulnerable structure.Gabions have advantages over more rigid structures, because they can conform to subsidence, dissipate energy from flowing water and resist being washed away, and they drain freely. Their strength and effectiveness may increase with time in some cases, as silt and vegetation fill the interstitial voids and reinforce the structure. They are sometimes used to prevent falling stones from a cut or cliff endangering traffic on a thoroughfare.

The life expectancy of gabions depends on the lifespan of the wire, not on the contents of the basket. The structure will fail when the wire fails. Galvanized steel wire is most common, but PVC-coated and stainless steel wire are also used. PVC-coated galvanized gabions have been estimated to survive for 60 years. Some gabion manufacturers guarantee a structural consistency of 50 years.

The term gabion refers to a modular containment system that enables rock, stone or other inert materials to be used as a construction material.

The modules or cages as they are known are formed of wire mesh fabric panels, jointed to form square, rectangular or trapezoidal shaped units. These units are part pre-assembled in the factory to form a flat pack system.

These flat pack units are then supplied to the customer and formed into the final shaped module on site with the necessary lacing wire, helical and / or rings as required. Each module has to be connected to adjacent modules to form a monolithic structure.

The types of mesh used, must be of a non ravelling type such as welded wire mesh or hexagonal woven wire mesh and provided with corrosion protection to suit the required exposure conditions.

The gabions are normally machined filled in layers with the contractor picking the stone over by hand to reduce excessive voids. The exposed faces are also systematically hand packed to provide an appearance of a dry-stone wall.

Although some structures are only machine filled, this procedure is not normally recommended. For gabion structures to perform correctly the quality of installation is of paramount important.

4.1 Construction

1. The proper technique for erecting gabion boxes and mattresses are clearly shown on the appropriate standard drawings and should be studied. Being a labour intensive operation, the contractor may well subcontract this work to an emerging subcontractor with limited previous experience of gabion work not to mention the local labour that may be employed for this purpose. The engineer's representative is strongly advised to instruct that a trial gabion box and mattress be assembled and packed at a convenient location before starting with the permanent works. In this manner off site training can be done until the engineer's representative is satisfied with the end product. The trial assembly should remain to serve as the norm for all subsequent work.

2. A group of assembled gabion boxes should be stretched to their proper length, width and height as described on the standard drawings. A sturdy frame should be used along the open side (the side not attached to an already packed box) to maintain the required height. In applications where not only the functionality but also the aesthetic appearance is important, it is highly recommended that the frame be faced with a solid board. This will go a long way to ensure an exposed gabion face with minimal bulging and unevenness's in its alignment.

3. To prevent bulging of the visible side of a box bracing wires must be used as shown on the drawings. This is particularly important when rounded stone is used which results in less internal friction. Although not called for on the standard drawing, it is good practice to brace all boxes, exposed or not, in this manner because it will assist them in maintaining their shape in case of flood damage or settlement.

4. The exposed side of a box should be lined with stone of near equal size neatly packed with a flat side up against the mesh. If rounded river stone is being used a special effort will be required to select flat faced stone for this purpose.

5. Gabion boxes should not be filled with mechanical equipment. The functionality of a gabion box is inter alia dependent on its mass which must be maximised by hand packing the stone in a manner that will minimise the voids. Smaller size stones should therefore be packed in between the larger stones. When working with rounded stone it has been found that oval shaped stone works better than spherical shaped stone in general.

6. The structural integrity of a gabion wall is dependent on its ability to function as a unit. The weakest link in this unit is the lacing together of the individual boxes and special attention needs to be given to this aspect.

7. Gabion mattresses on a slope must be laid with the 1 m spaced diaphragms parallel to the slope even though this may result in more cutting and lacing having to be done. In this manner, there is less chance for the stone to be displaced by gravity and water forces towards the lower side. For similar reasons mattresses laid flat should be laid with the diaphragms square to the direction of flow.

8. For mattresses the normal spacing of the brace wires is one brace per 1 m2. When working with rounded stone it is recommended that the brace spacing be halved.

9.Where gabion mattresses are laid on a slope and the top edges are to be fixed to a concrete element e.g. slope protection for a low level river structure, a detail will have been provided on the drawings for the manner in which the mattresses are to be fixed to the concrete element. The mattresses should be fixed to the concrete element in the manner specified before they are filled with stone because once they are filled they will tend to slump slightly and an undesirable gap will develop between the top edge and the concrete which cannot easily be rectified.

10. For added protection against wear and tear caused by boulders transported by flood waters, a concrete screed on top of the gabion mattresses may be specified. A dry mix which will not unnecessarily penetrate into the mattress and placed to a thickness of 50 mm above the wire mesh, works well. Dry joints should be formed at 1 meter intervals to maintain some measure of flexibility and to allow for seepage water to escape. This technique applied to small patches (say 300 mm by 300 mm) in a regular pattern will also discourage theft of the wire mesh.

4.2 Planning Considerations

For easy handling and shipping, gabions are supplied folded into a flat position and bundled together. Gabions are readily assembled by unfolding and binding together all vertical edges with lengths of connecting wire stitched around the vertical edges. The empty gabions are placed in position and wired to adjoining gabions. They are then filled with cobblestone-size rock (10-30 cm in diameter) to one-third their depth. Connecting wires, placed in each direction, brace opposing gabion walls together. The wires prevent the gabion baskets from "bulging" as they are filled. This operation is repeated until the gabion is filled. After filling, the top is folded shut and wired to the ends, sides, and diaphragms. During the filling operation live rooting plant species, such as willow, may be placed among the rocks. If this is done, some soil should be placed in the gabions with the branches, and the basal ends of the plants should extend well into the backfill area behind the gabion breast wall.

Several different design configurations are possible with gabions. They may have either a battered (sloping) or a stepped-back front. The choice depends upon application, although the stepped-back type is generally easier to build when the wall is more than 10 feet high. If large rocks are readily accessible, inexpensive, and near the proposed site, then their use in construction of a rock wall may be preferable. On the other hand, if rock must be imported or is only available in small sizes, a gabion wall may be preferable.

4.3 Sequence of Construction

Since gabions are used where erosion potential is high, construction must be sequenced so that they are put in place with the minimum possible delay. Disturbance of areas where gabions are to be placed should be undertaken only when final preparation and placement can follow immediately behind the initial disturbance.

Where gabions are used for outlet protection, they should be placed before or in conjunction with the construction of the pipe or channel so that they are in place when the pipe or channel begins to operate.

4.4 Maintenance

Gabions should be inspected on a regular basis and after every large storm event. All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function. All maintenance and repair shall be conducted in accordance with an approved manual.

4.5 ADVANTAGES

- Ease of handling and transportation
- Speed of construction
- Flexibility (Gabions tolerate movement)
- Permeability to water (Good drainage)
- Gabions offer an easy-to-use method for decreasing water velocity and protecting slopes from

4.6 DISADVANTAGES

- Gabions are sometimes criticized as being unsightly. They can be made more attractive by use of attractive facing stone toward the front of the wall and by establishing vegetation in the spaces between the rocks.
- Low habitat value.
- Gabions are more expensive than either vegetated slopes or riprap.
- The wire baskets used for gabions may be subject to heavy wear and tear due to wire abrasion by bedload movement in streams with high velocity flow.
- Difficult to install, requiring large equipment.

BRUSHWOOD CHECK DAM

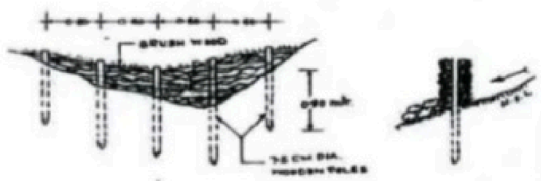
Brushwood check dams are constructed with the help of locally available wooden poles and brushwood. Wooden poles are driven into the ground in a single or double row across the nalla and brushwood is packed on the upstream face of the check dam.

5.1 Suitability

This type of check dams is provided in small and medium gullies where wooden poles are locally available and the side slope of the gully is less than 45degrees. Depending upon the size of the gully and area of catchments, poles of about 7.5 cm dia. are driven into the ground in a single row or a double row across the nallas at right angle to flow and accordingly these are called single row or double row brushwood check dams. Single row brushwood check dams are used in small gully heads not deeper than 1.00 mtr. Whereas in case of medium gullies (up to about 2 m deep and 6.00 m wide) double row brushwood dams are most suitable. The posts used should preferably be of species Lanneacoromandelica, Sisso and Ficus which will strike roots.

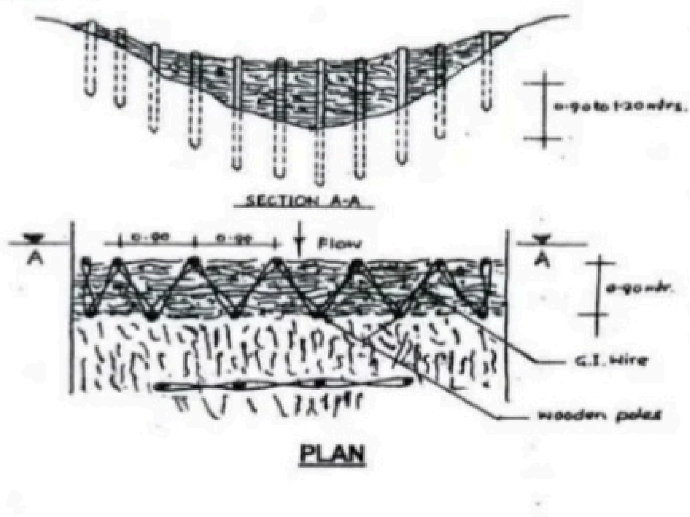
SINGLE ROW BRUSHWOOD CHECK DAM

Figure I



DOUBLE ROW BRUSHWOOD CHECK DAM

Figure II



PLAN

5.2 Design Specifications

(a) Single row brushwood check dam:

In case of a single row check dams wooden poles are driven 90 cms deep into the ground and the centre to centre spacing between two consecutive poles should be 60 cms. The height of the poles in the middle of the nallas bed should be 30 to 60 cms less than those of the poles on the banks so that a deep concave curve is formed at the top to dispose of excess water. The brushwood is packed against the u/s face of the poles and on the downstream side brushwood matting is laid out which acts as an apron for the dam and protects the downstream from erosion. The wooden stakes may be treated with coal tar/creosote oil to protect them from attack by white ants. For a brushwood check dam, an average height of about 0.3-0.7 m is usually considered to be satisfactory.

(b) Double row brushwood check dam:

In case of a double row brush wood check dam, poles are placed about 90 cms apart in two parallel rows and the embedment of these poles into the nallas bed should be 90 to 120 cms. The distance between two rows should not exceed 90 cms. and the poles are tied up with GI wire. The straw and brushwood is laid across the gully between two rows of wooden posts and a brushwood apron held by galvanized iron bar is necessary to prevent scouring.. A brush wood apron held by galvanized iron wire is necessary to prevent scouring.

(c) Other details:

Brushwood check dams made of posts and brush are placed across the gully (Fig. 14). The main objective of brushwood check dams is to hold fine material carried by flowing water in the gully. Small gully heads, no deeper than one meter, can also be stabilized by brushwood check dams. Brushwood check dams are temporary structures and should not be used to treat ongoing problems such as concentrated run-off from roads or cultivated fields. They can be employed in connection with land use changes such as reforestation or improved range management until vegetative and slope treatment measures become effective.

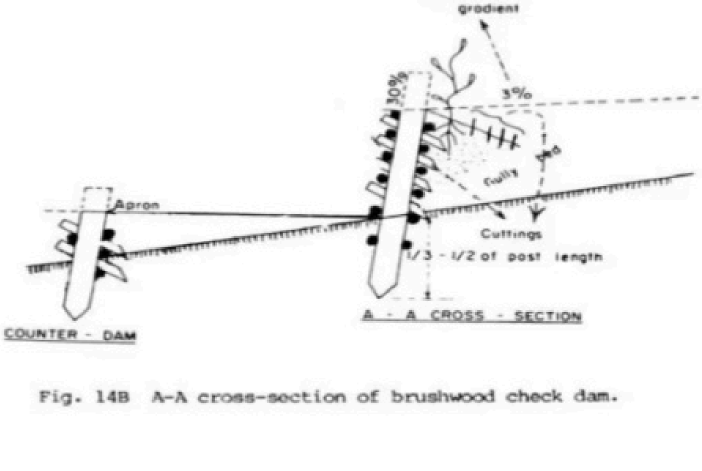


Fig. 14B A-A cross-section of brushwood check dam.

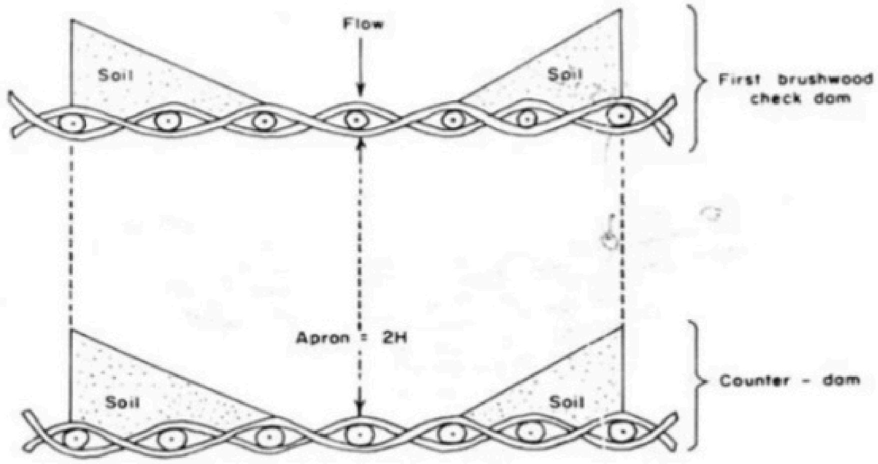


Fig. 14C Top view of the first brushwood check dam including the counter-dam.

If soil in the gully is deep enough, brushwood check dams can be used in all regions. The gradient of the gully channel may vary from 5 to 12 percent, but the length of the gully channel, beginning from the gully head, should not be more than 100 meters. The gully catchment area should be one ha or less.

There are many types of brushwood check dams. The type chosen for a particular site depends on the amount and kind of brush available. Whatever sort is used, the spillway crest of the dam must be kept lower than the ends, allowing water to flow over the dam rather than around it.

The maximum height of the dam is one meter from the ground (effective height). Both the upstream and downstream face inclination is 30 percent backwards. The spillway form is either concave or rectangular.

(d) Other specifications for brushwood check dams:

Posts are set in trenches (0.3 by 0.2 m in size) across the gully to a depth of about 1/3 to 1/2 of the post length, and about 0.3 to 0.4 m apart. -The length of the posts is 1.0 to 1.5 m and their top-end diameter is 3 to 12 cm.

Any tree or shrub species, such as alnus, pine, bamboo, salix, poplar, etc., can be used as posts.

The flexible branches of trees (Salix, Poplar, Glirecidia, Cassia, etc.), flexible stems of shrubs (Tithoniarg andis, Tamarix, Arundinaria intermedia, etc.), and the strips made of bamboo stems may be used as interlink material. These materials are woven between wooden posts driven into the ground.

The ends of interlink materials should enter at least 30 cm into the sides of the gully.

The space behind the brushwood check dams must be filled with soil to the spillway.

If sprouting species (Salix, Poplar, Tithonia grandis, etc.) are selected as posts and interlink materials, brushwood check dams should be constructed when the soil in the gully is saturated or during the early rainy season.

If nonsprouting species (pine and alnus as posts, bamboo strips as interlink materials) are used, brushwood check dams can be constructed during any season.

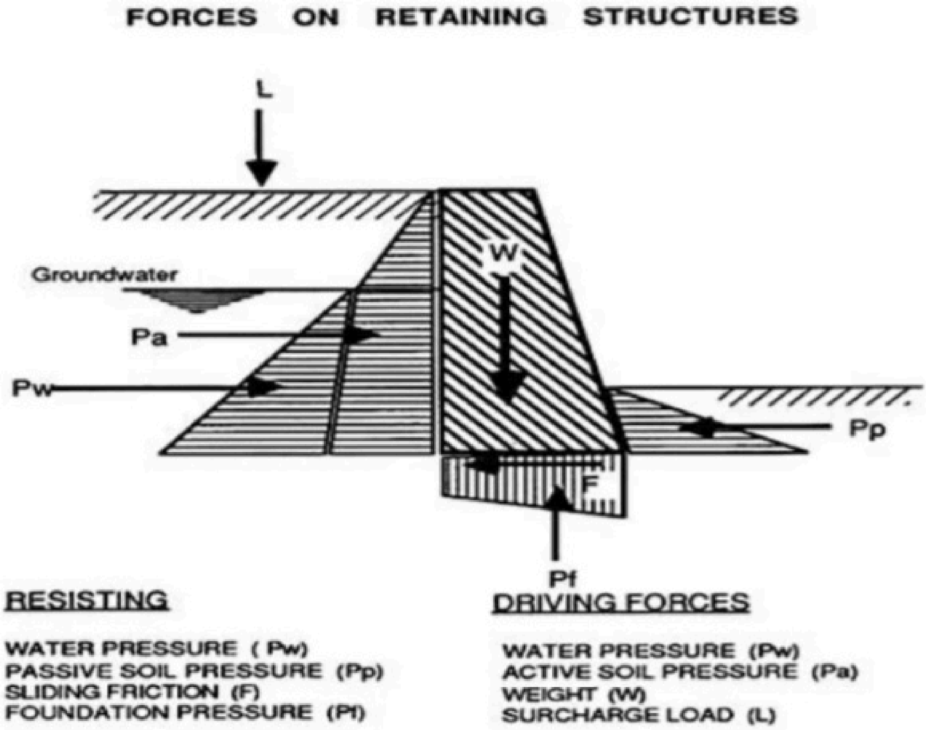
SMALL MASONRY STRUCTURES

Definition

It is a masonry structure that intercepts water foam local catchment and stores it for optimum utilization. Such structures not only reduce the erosive velocity of runoff but also prevent gullies from further enlargement. The water retained on upstream side or behind the structure can be used for lift/ gravity irrigation and as drinking water for people, as well as for cattle and other animals. It also helps recharging wells downstream.

Retaining wall

- The volume of cribs or retaining walls should be 1/6 to 1/10 of that of the of moving mass to be retained. As a rule, the foundation or base should at least extend 1.2 to 2.0 meters below the slip plane in order to be effective. The forces acting on a retaining wall are similar to those acting on a natural slope. These forces are be grouped into resisting forces (forces resisting failure) and driving forces (forces causing failure) as illustrated.
- Thus, retaining wall is constructed on small streams so as to prohibit flow of water and allow it to seep underground and increase the potential of the ground water storage.



BANDHARA

- Bandhara is a permanent type of structure constructed to dam the flow of water from small streams and rivers.
- These structures are constructed as minor irrigation system to tap water and allow it to be used for irrigation as well as to let it seep into ground resulting in increase in water table along the downstream side. These are small weirs, and canal are taken off from them for irrigation of small areas.
- A series of such dams or bandharas or weirs are constructed and water available in monsoon is thus made use of.

LOCATION OF BANDHARA

- The river or stream on which Bandhara is to be constructed should preferably be a perennial one so that the water is available from the river all through the year.
- At the site, good foundation should be available for construction of Bandhara.
- The section at site should be straight, narrow and well defined.
- The natural banks on both sides of site should be high enough so that no land is submerged on upstream side.
- The cost of construction on the site should be low

WORKING OF BANDHARA SYSTEM

- The Bandhara are always constructed in a series so that water spilling from one Bandhara is checked by other Bandhara.
- Each Bandhara and canal systems taking off from Bandhara forms one complete unit.
- The water is controlled by a head regulator.
- The water gets collected in Bandhara from the stream and is allowed to penetrate into ground and increase the groundwater table of that area as well as it is used for irrigation purposes.
- Hence, it is a simple technique of watershed management and can be constructed when sufficient funds and labor is available.

DESIGN OF BANDHARA

- The design procedure for the Bandhara is a simple one.
- The weir length (surplus weir) has to be designed and/or calculated.
- The method of calculating the weir length and the capacity are the same in all cases of situations. The procedure is as follows:
    1. Select the site for the tank or check dam.
    2. From the topo sheet or village map, find out the correct catchment area of the watershed at that location.
    3. Take the cross sections and longitudinal section of the stream or gully where the tank or dam is constructed.

4. Based on the levels taken, prepare 50 cm contour for sufficient area to decide the water spread area and the capacity of the tank based on the yield of the watershed.

- Example:

Catchment area	- 40 ha
Monsoon/Rainfall season	- 625 mm
Yield from catchment assuming the catchment is good (more yield) tables are available.	- 51 480 m^3
Capacity may be designed as 1/3 of the yield from the catchment i.e.	- 17 000 m^3

- Deciding full tank level (FTL), Maximum water level (MWL) and tank bund level (TBL):
- From the levels taken, draw the contour lines at every 50 cm interval between the bed level and the highest ground level at the site. From these contour lines, the capacity of the tank at 0.5 m, 1.0 m, 1.5 m and 2.0 m height above the bed level is calculated. The contour (level) at which the tank can store 1/3 of 51 400 m^3 i.e. 17 000 m^3 is the required height of the weir. That is called full tank level (FTL). For small tanks, the height of flow over weir is taken between 0.30 - 0.60 m and this level is known as maximum water level (MWL). The tank bund level (TBL) is calculated by adding 1m or more based on the height of the water stored above the bed level of the tank.
- Maximum Discharge Q = CIA/360

Where Q= Discharge in cumec

I = Intensity of rainfall (25 mm/hour)

A = Area of catchment in ha.

- To decide the length of the weir

$Q = CLH^{3/2}$

$= 1.67\ LH^{3/2}$ (broad crested weir C = 1.67)

$L = Q/CLH^{3/2} = CIA/360\ CLH^{3/2}$

Where C = Constant =1.67

L = Length of the weir

H = Flow height over weir

- After deciding the length of the weir (L), other structural calculations may be made, including the body wall, wing walls and apron. Finally the stability of the structure is checked.

ADVANTAGES OF BANDHARA SYSTEM

1. If implemented as a irrigation system, it supplements the Water Management too and is comparatively low in initial cost.
2. Small quantities of water which would have otherwise gone waste is utilized to a maximum in this system.
3. As the length is small, evaporation losses are very less and the seepage increases raising the groundwater table.

DISADVANTAGES OF BANDHARA SYSTEM

1. The irrigable area for one bandhara is more or less fixed and, hence, if greater quantity of water is available it may go waste if any other bandhara is not available to tap water further.
2. If river or stream is of non-perennial type, the supply of water becomes seasonal and unreliable in summer.
3. Small sources of water are dammed; hence the population living on downstream side which depends upon river or stream for water supply goes without water during dry periods.

SUITABILITY OF BANDHARAS

Bandhara system is suitable for isolated catchments. It is also very suitable in tracts where there are number of small rivers and streams.

CONTOUR BUNDING

Contour bunding is one of the simple methods of soil and water conservation. Bunding is an embankment of earth. It plays an important role in soil and water conservation in the field with medium slope. In between two contours agriculture can be practiced. Along bunds trees which fix nitrogen into soil are planted with grass.

7.1 METHOD OF CONSTRUCTION

1. For bunding first step is to mark contours on agricultural fields.
2. The bunds are taken along the contour.
3. The height of bund should be 0.3m and top width 0.3m
4. The slopes should be 1(V):1(H).
5. Spacing of bunds will depend upon slope of land.
6. Along bunds grassland can be developed along with tree plantation.
7. Trees which will satisfy basic needs of a village can be planted on downstream side of a bund
8. When in between two bunds agriculture is practiced tree plantation on bund is possible.
9. Trees will be useful for compost which will improve fertility of soil.

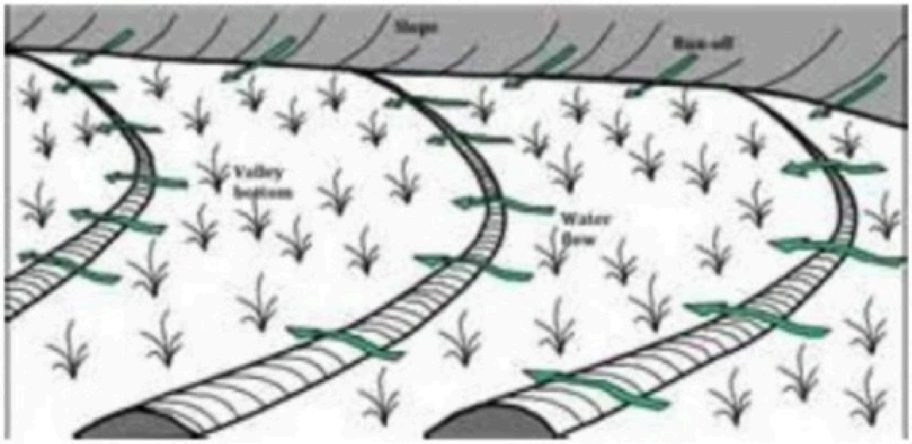
7.2 WORKING OF CONTOUR BUNDING

1. When there is rainfall, contour bund acts as a barrier to water flow and checks the velocity.
2. This reduces chances of soil erosion.
3. When water starts flowing along fields, bund becomes obstruction for it.
4. Due to obstruction velocity reduces and water percolates behind bunds.
5. This allows infiltration of water into the soil.
6. Thus, bunding on fields with moderate slopes helps in soil and water conservation.

7.3 SUITABILITY

1. Maharashtra state percentage of barren land along the sloppy agricultural land is quite large.
2. Due to slope, soil and nutrients erode fast which makes agriculture on this land very uneconomical.

3. People having such type of land can adopt this technique.
4. Also this technique can be adopted on plain land.

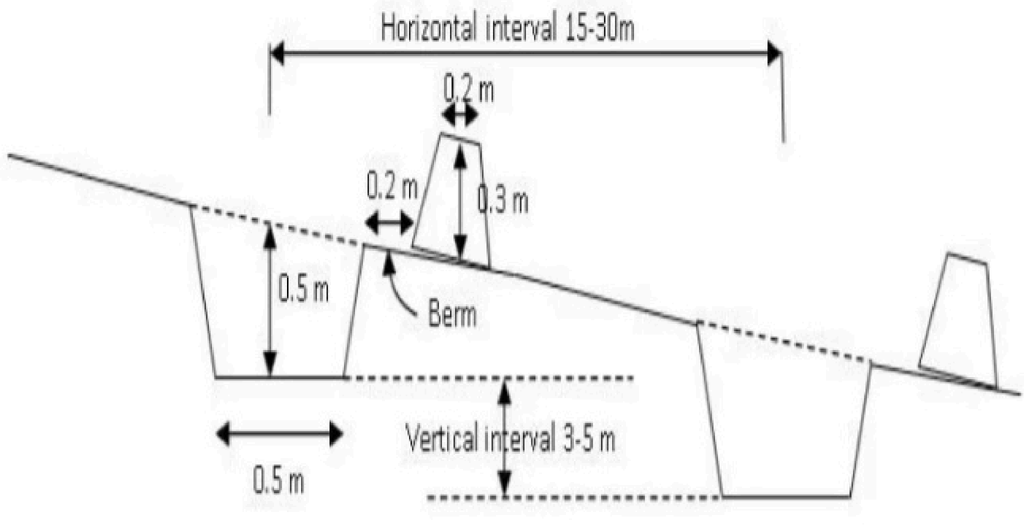


7.4 OUTPUT OF CONTOUR BUNDING

1. Soil along sloppy fields is protected from erosion caused by flowing water. Thus work of soil conservation is done without any special hi-tech technique.
2. Huge biomass generated along bunds which can be used for cattle as fodder and compost used as an organic matter.
3. As flowing water is obstructed, rate of infiltration is increased.
4. Income level from eroded land increases.
5. Income generation from trees in the form of fodder, nitrogen in the soil, fruits, fuel, green manure

CONTOUR TRENCHING

Contour trench construction is an extension of the practice of ploughing fields at a right angle to the slope. Contour trenches are ditches dug along a hillside in such a way that they follow a contour and run perpendicular to the flow of water. The soil excavated from the ditch is used to form a berm on the downhill edge of ditch. The berm can be planted with permanent vegetation (native grasses) to stabilize the soil. Contour trenches are not irrigation channels, rather they are used to slow down and attract runoff water, which they infiltrate into soil. Small scale contour trenches can also be used within field level. The water that infiltrates can be used as soil moisture for crops cultivated after a rainfall event, directly for pumped irrigation, or extracted from shallow wells in the area.



8.1 DATA TO BE COLLECTED

1. Catchment area details, from topographical maps.
2. Detailed rainfall data.
3. Soil infiltration rates and soil properties based on physical soil investigation.

8.2 TRENCH DIMENSION

1. Once the area, rainfall data, soil data are collected, then total trench capacity can be determined.
2. Runoff volume minus what would infiltrate in trenches during rainfall event would be the trench capacity.
3. Accordingly trench dimension and spacing can be calculated.
4. Trenches should be over dimensioned to allow long term runoff volume to be stored.

8.3 SUITABILITY

1. In natural runoff areas but not on slopes over 10%.
2. Soil in vicinity has sufficient infiltration capacity and potential sub-surface storage capacity.
3. In areas, which have very heavy storms, it may be dangerous to allow water completely from flowing down a slope. So constructing trenches to drain excess water is best method.

VEGETATIVE BARRIER

Vegetative barriers or grass hedges are currently being evaluated as an alternative conservation practice. Vegetative barriers are narrow strips (1-3 feet wide) of stiff, erect densely growing plants, usually grasses, planted across the slope perpendicular to the dominant slope.

The main purpose of vegetative barriers is to:

1) Retard and reduce surface runoff by promoting detention and infiltration.

2)Disperse concentrated flow and prevent ephemeral gully development.

Secondary benefits that sometimes can be realized are:

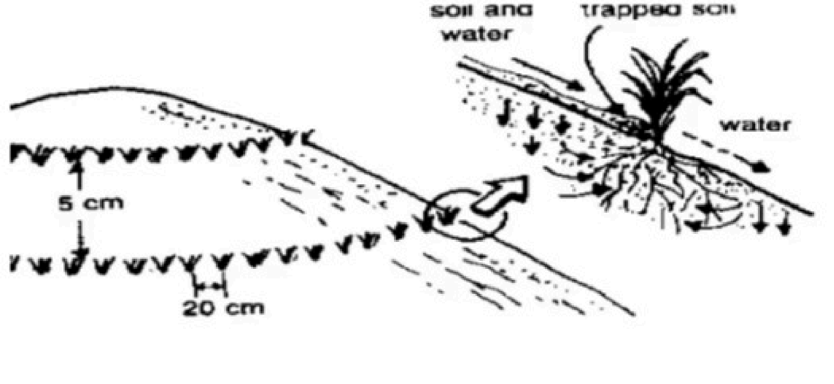
1) Facilitate benching of sloping topography.

2) Provide valuable wildlife habitat.

9.1 CONCEPT OF USE

Erosion, whether caused by wind or water, accounts for the loss of tons of soil every year. Gully erosion is the most obvious form of erosion with the deep down cutting of the soil profile. Raindrops pound the ground dislodging soil particles which are carried away by the surface runoff. Sheet erosion is a slow but steady form of erosion that covers vast amounts of acreage. Erosion can be controlled in two different ways. 1) The surface can be protected or reinforced by residue or through vegetation such as pastureland or a grass waterway. 2) The surface or slope can be flattened through benching or terracing. These barriers inhibit surface runoff, slowing and ponding water and capturing and preventing sediment from flowing downhill.

Vegetative barriers inhibit the flow of water because of their dense concentration of thick stems, thus slowing and ponding water and causing sediment to deposit in back of them .Over time these deposits can develop into benched terraces .These barriers function to diffuse and spread the water runoff so that it slowly flows through them without erosion.



9.2 PLANTING TECHNIQUES

Successful grass hedge plantings require the selection of the appropriate grass species, good land preparation, proper planting and sound management following establishment.

9.3 TERRACES

① Seeding

The appropriate grass species for seeding vegetative barriers is a perennial species which produces an abundance of stiff erect stems that are resistant to water flow and tolerant of sediment deposition. They must be tolerant to the following:

(a) Herbicides used on adjacent cultivated crops;

(b) Partial shading from cultivated crops;

(c) Inundation by sediment;

(d) Local climatic extremes (wetness, drought, freezing temperatures, etc); and,

(e) Easily established from available materials.

They must also have the following characteristics:

(a) Long lived and manageable as a narrow strip;

(b) Non-weedy and not too competitive with adjacent cultivated crops; and

(c) Relatively tolerant to defoliation if crop residues are grazed.

② Grass Selection

"Alamo" switch grass has frequently been selected for vegetative barriers in Texas. Its seed characteristics make it easy and cost efficient to use. It produces a tall dense growing hedge and has good drought tolerance and range of adaptability. Good quality seed with a high germination rate should be purchased from a reputable dealer on a pure live seed (PLS) basis. It is necessary to establish a dense concentration of seedlings in order to quickly develop a solid vegetative barrier

③ Seed Bed Preparation

A major cause of seeding failures is poor seedbed preparation. Seedbed preparation needs to be initiated well ahead of the actual planting. Two types of seedbed preparation are generally used for vegetative barrier seeding, no-till and clean till. A no-till seedbed will usually have had a prior season's crop such as wheat or grain sorghum. This crop must be shredded and then shortly before seeding the field must be sprayed to kill any weed competition. A clean seedbed simply uses tillage to provide a clean, weed-free, smooth and firm seedbed. A disk followed by a cultivator is the most frequently used tillage operation to provide a clean, weed-free seedbed. However, a loose or rough seedbed will prevent accurate placement of the seed in the soil. Furthermore, it will prevent good seed to soil contact which is required for good germination, emergence and drought tolerance for the small grass seedling.

④ Seeding Procedures

The width of the vegetative barriers should be a minimum of 3 feet wide. If planted with a Brillion seeder the width is generally 5 feet wide. If planted with a no-till drill, it usually is seeded with the middle 6 rows of an 8 row drill at ten inch spacing between rows. Switch grass should be planted between one-quarter and one-half inch deep. Once the vegetative barrier is well established the barrier can be maintained at 3 feet wide with cultivation. In a no-till operation, placement of seed is best attained with a no-till drill that is equipped with double disk openers and depth bands. A firm seedbed and appropriate tension on the disk openers should prevent the disk openers from submerging too far below the soil surface or running above the soil surface. In a clean-till operation, a Brillion seeder for switch grass can also provide a good seeding. Prior cultivation should provide a clean weed-free seedbed.

There are numerous advantages to vegetative barriers. Seeded terraces are less expensive to construct than conventional earthen terraces. There is less earth movement and soil compaction. Vegetative barriers can reduce concentrated water velocities. It can revitalize and support waterways by capturing and spreading eroded sediment. It can enhance nutrient uptake of filter areas. Vegetative barriers can provide a cost effective technique for water and sediment control basins. Furthermore, vegetative barriers can provide critical wildlife habitat when annual crops deteriorate.

CONCLUSION

To depict all the discussed methods of watershed management, a model watershed with all the techniques is prepared and is made a supplement to this project report. The overall effort is to make the concept of watershed management appreciable to all and inspire one and all adopt the techniques as per the requirement of the situation.

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