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 erodible stream embankments.

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

1) Reduction in soil erosion
2) Trapping silt, which reduces the rate of siltation in water harvesting structures in the lower reaches of the watershed
3) Increasing recharge of groundwater
4) 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

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

LOCATION:

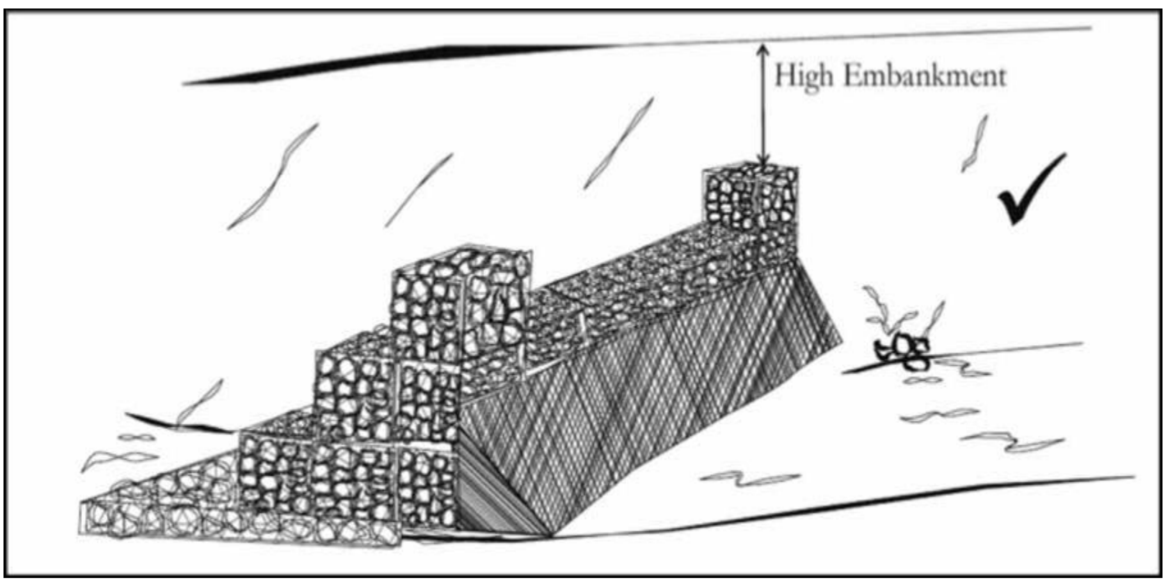

Figure: Gabion structures should be made where the embankments of the drainage line are high as shown above

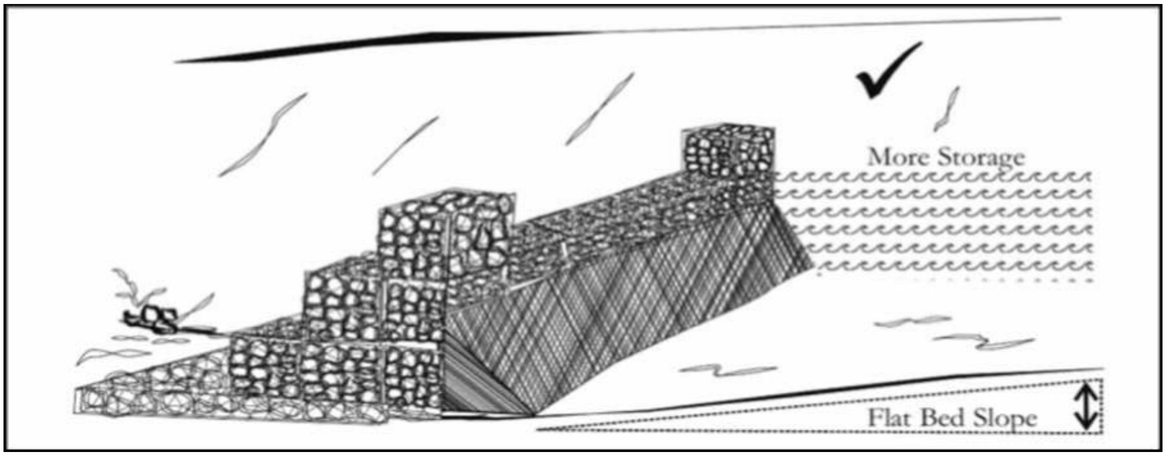

Figure 2-29: Gabion structures should be made where the bed slope is flatter

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 erodible 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.

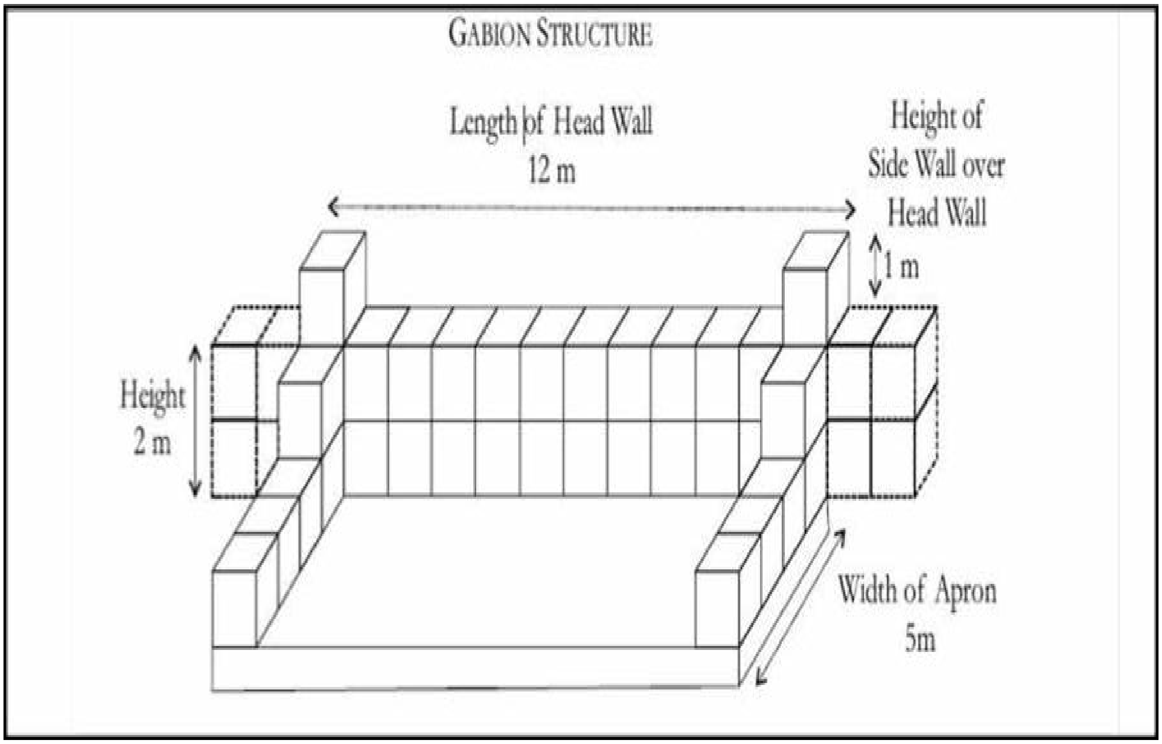

Figure 2-30: Gabion Structure

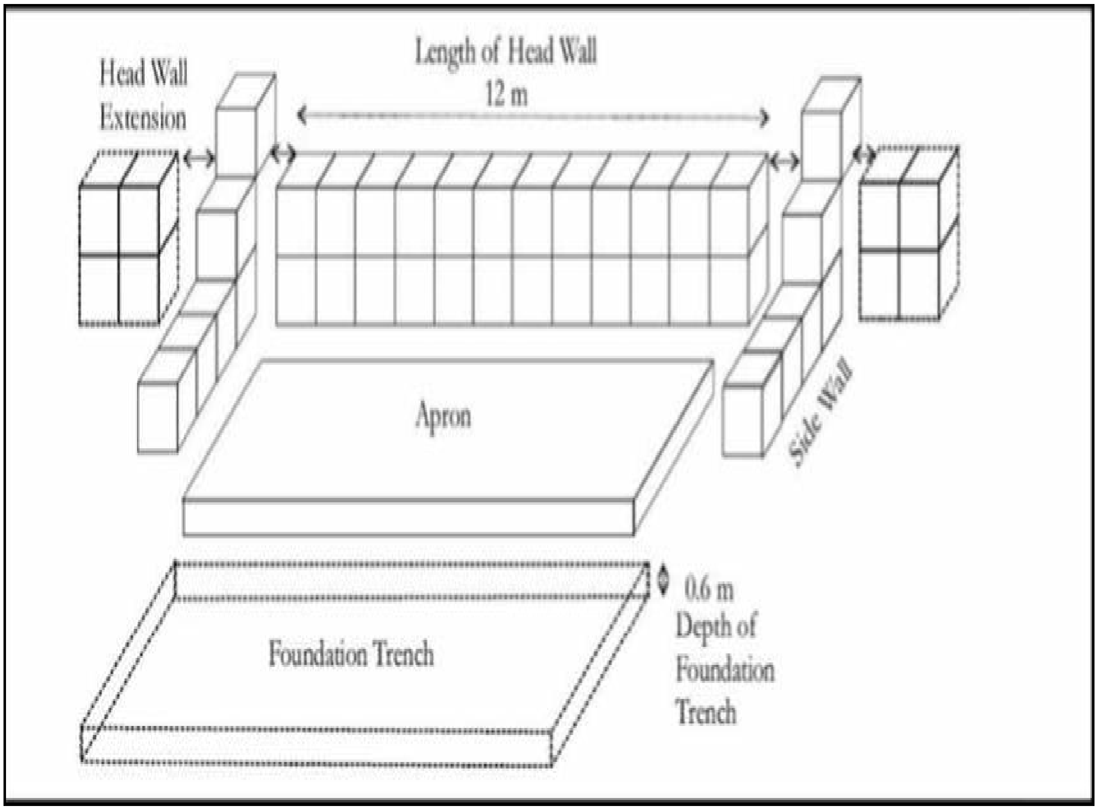

Figure: Different parts of the gabion

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:

Problem

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.

Solution

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.

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 DONTs:

DONTs

a) Do not build a gabion structure where the embankment is highly erodible 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.