CHAPTER 12

FLOOD FIGHTING

From ancient times, villagers and farmers living in river deltas have acquired considerable experience developing voluntary efforts to defend their lives, crops and property against frequent flooding. Whenever flood or storm surge threatened, groups of flood fighters have sprung to the defence of their villages and have done what they could to minimize loss and damage. Although flood fighting has traditionally been thought of as a local, self-help responsibility, it has long been realized that when a flood constitutes a threat to a number of neighbouring communities, co-ordinated action under unified control is much more effective than independent action by each community.

Flood fighting can be defined as the taking of precautionary measures against disaster at times of flood and storm surge. These measures should aim to prevent damage or to minimize its extent, to protect life, limb and property and, in general, to ensure the safety of the population. Successful flood fighting and the attainment of the above goals depend upon good organization, thorough advance planning, well-trained personnel and the effective co-ordination of operations at local, provincial and national levels.

Flood-fighting corps

Legislation for disaster preparedness should provide for a flood-fighting corps in each vulnerable town or village with responsibility for the planning and conduct of flood-fighting operations. Each corps should consist of a small full-time cadre and a much larger part-time staff. In Japan, where flood fighting is highly developed, there were in 1973 some 3000 flood-fighting organizations with a total of 20000 full-time personnel and more than one million part-time staff.

Before the flood season, each flood-fighting corps should conduct field exercises and practical demonstrations of flood-fighting methods, including trials of evacuation and rescue operations. Arrangements should be made for additional manpower to be made available when necessary, both from within the local area of the flood-fighting corps and from neighbouring towns and villages. This additional help may be required when, for example, there is a risk of a dike being breached by flood or storm-surge waters. At such a time the local flood-fighting corps may be unable to ensure the protection of the area with its own resources. Furthermore, the public should be trained and educated to co-operate actively with the flood-fighting corps during emergency operations because under such conditions it may be necessary to mobilize the services of all available inhabitants.

Those participating in flood-fighting operations should be adequately insured because of the significant risk of death or serious injury.

Advance planning of flood-fighting operations

For flood fighting to be successful, careful advance planning of all aspects of the operations is necessary. The planning should cover all those who will be involved from the flood-fighting corps, municipality, town or village officers and general public to the regional and central government.

As a first step, responsibilities should be defined. Usually, the central government will give advice and provide financial assistance to regional governments and to local flood-fighting organizations. At the regional level, the authorities may co-ordinate and assist emergency operations carried out by the local flood-fighting corps. When

necessary the public works department of the central and regional governments should furnish the heavy equipment required for the construction of emergency dikes. At the community level, the city, town or village authorities which control the flood-fighting corps will be responsible for carrying out the actual emergency operation. If it is considered to be more suitable, several towns or villages may group themselves together in establishing a jointly managed flood-fighting organization for the total area covered by those towns or villages.

Advance planning for flood-fighting operations should cover the following points:

(*a*) Areas of responsibility, organizational system and duties;

(*b*) Patrols and watches along dikes and embankments,

(*c*) Communication and transportation facilities;

(*d*) Procedures for the operation of dams, sluices and lockgates;

(*e*) Warnings for flood-fighting operations;

(*f*) Mobilization of flood-fighting corps;

(*g*) Co-operation with other flood-fighting organizations and arrangements for mutual assistance;

(*h*) Supplies and the stocking of depots with tools, equipment and other material needed for flood-fighting operations.

The Imba-Tone River Flood Defence Association in Chiba Prefecture, Japan, provides a good illustration of how flood fighting can be organized at the local level. As shown in Figure 13, it consists of three cities and seven towns along the right bank of the lower Tone River which have joined together for the purposes of flood-fighting operations. When serious flooding is expected, more than four thousand members of the flood-fighting corps are mobilized. A headquarters, four branches and ten depots for flood-fighting operations are established under the operational plan which has been drawn up to protect some 11 km of embankment.

Equipment and material for flood-fighting operations

A combination of sufficient trained manpower, adequate stocks of well laid-out material, telecommunication equipment, construction machinery and vehicles for transport are necessary for effective flood-fighting operations. All the above equipment and material should be carefully inspected each year before the rainy season begins. It is also desirable that the flood-fighting corps should be equipped with walkie-talkies for ease of communication. Vehicles should be equipped with sirens to be used for warning and other specified purposes. Warehouses or depots should be set up in protected areas along the river embankment so that tools such as pickaxes and shovels, sandbags, lumber, ropes and wire are readily available for emergency use.

In providing these supplies it is desirable to prescribe the quantities of each item that will be required in a given area. In making this decision the particular river conditions, extent of embankment, experience gained through past disasters in the area, and the number of people in the flood-defence force should all be taken into account. Table IV shows the quantities recommended by the Ministry of Construction in Japan for a depot in an important levee protection area.

Flood-fighting warnings

On the issue of a tropical cyclone warning, each town and village in areas concerned should place its flood-fighting corps on stand-by alert. If and when a flood warning is issued, the flood-fighting corps should be mobilized at a state of full alert. Table V on page 71 illustrates how various stages of alert can be applied to the monitored water-level at a designated point along the river.

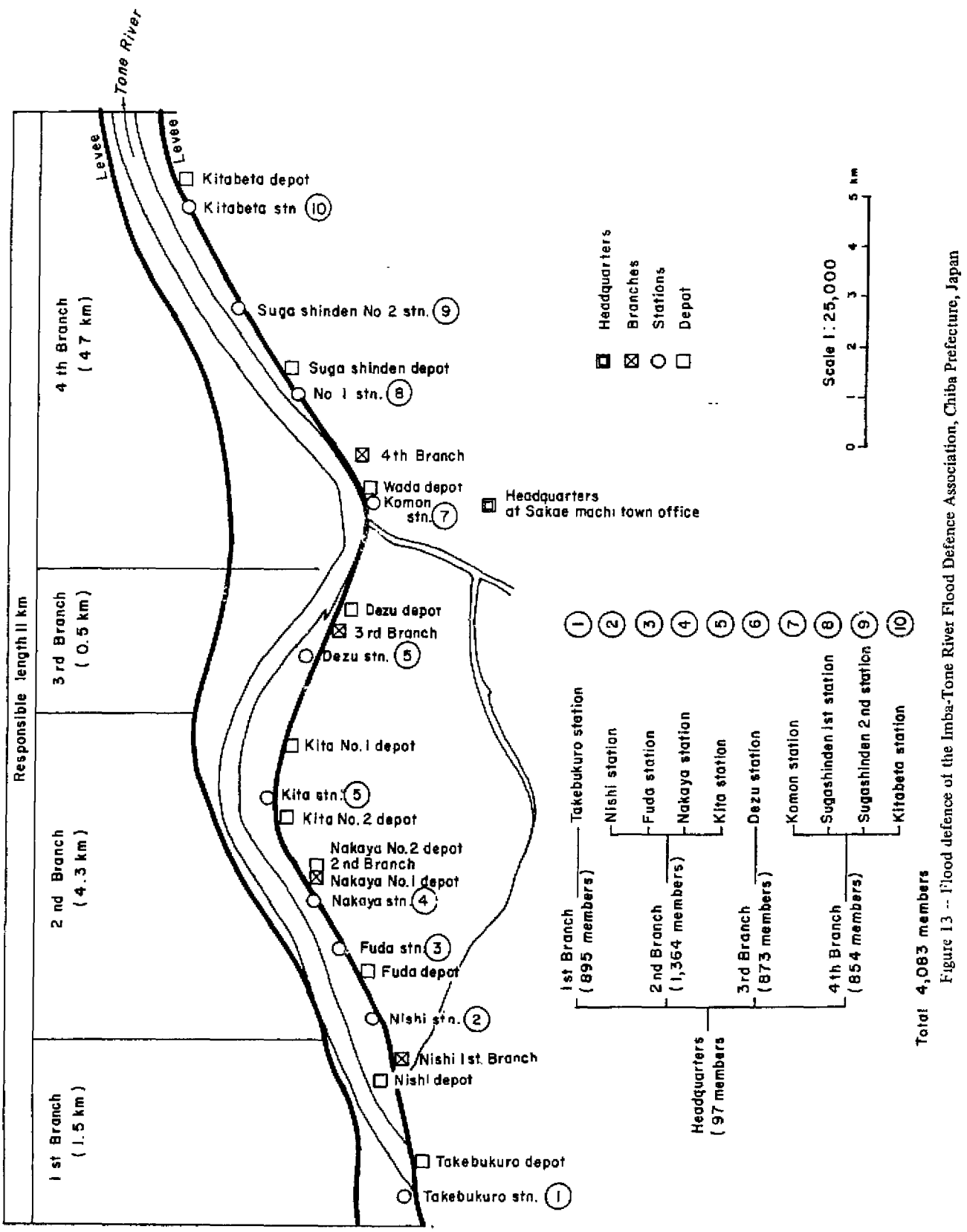

Figure 13 -- Flood defence of the Imba-Tone River Flood Defence Association, Chiba Prefecture, Japan

TABLE IV

Standard of supplies to be stored in a levee protection depot in an important levee protection area

Item	*Quantity*	*Item*	*Quantity*	*Item*	*Quantity*
Straw bags or empty rice bags	600	Shovels	30	Bonfire stands	8
Rope	550 kg	Mauls	10	Large lights	3
Straw mats	100	Saws	4	Large paper lanterns	2
Cedar logs of end diameter 9 cm, length 5.1 m	10	Sickles	10	Candles	1 kg
Cedar logs of end diameter 9 cm, length 3.6 m	30	Axes	5	Carbide	50 kg
Cedar logs of end diameter 9 cm, length 1.8 m	200	Cutting pliers	3	Firewood	400 kg
Bamboo	15	Hand rammors	8	Torchwood (pine)	200 kg
Bamboo baskets	20	Steel wire No. 8	100 kg	Straw baskets	50
		Steel wire No. 10	100 kg	Poles for shouldering	50
		Clamps	50	Scaffolding planks	2
		Ladder	1	Cobble	Some
		Bucket	1	Reserve soil	Some

Note. – Ten depots of this type are provided along 11 km of levee of the Imba-Tone River Flood Defence Association (as shown in Figure 13).

TABLE V

Nature and stages of flood-fighting warnings

Stage	*Nature of alert*	*Action involved*	*Time of announcement*
1	Stand-by	Placing of members of the flood-fighting corps on stand-by	Coincides with issue of tropical cyclone warning
2	Preparation	Inspection of major material and equipment for flood fighting, preparations for opening and closing of weirs and gates, mobilization of senior members	When the specified water-level is reached
3	Mobilization	Mobilization of members of the flood-fighting corps	On issue of flood warning and/or when the warning water-level is reached
4	Dismissal	Termination of flood-fighting activities	When the water-level is observed to decrease from the warning level and there is no necessity for further flood-fighting activities
From time to time	Water-level	To announce water-level conditions such as rise and fall of water-level, period of time at given level, magnitude and time of occurrence of maximum water-level, etc., which are deemed necessary for flood-fighting activities	From time to time, the observed and predicted water-levels on both rise and fall are announced

Threshold and warning levels for each gauging station should be specified in the flood-fighting plan and advance notice sent to the local flood-fighting organizations. In order that the water-resources agency may decide when a flood-fighting warning shall be issued, the water-levels at gauging stations along rivers and sea coasts should be reported

as frequently as necessary, whenever the designated threshold value is reached. When a flood-fighting warning is issued, its contents should be conveyed without delay to the chief of the local flood-fighting organization, using the telecommunications networks as prescribed in the flood-fighting plan.

Operation of reservoirs

The operation of an impounding reservoir, used primarily for the storage of water, should be subject to procedures based on long-term streamflow records. In this way it should be possible to avoid an artificial flood downstream. This could occur if the reservoir is at maximum capacity and, as a result of continued inflow from prolonged rainfall, it becomes necessary to release water from the reservoir.

Operation of flood-control gates and locks

Water-levels increase very rapidly when a storm surge, tidal wave or flood occurs in the downstream section of a river. Water-levels should therefore be constantly monitored so that the opening and closing of gates may be dealt with efficiently. Attention should be paid to flood forecasts and warnings and the local inhabitants should be notified by means of an alarm bell when the gates are to be opened or closed.

Need for close liaison

The operation of locks and gates in the upper parts and downstream of the same river, or within the same area, must be completely co-ordinated. Arrangements should therefore be made for close liaison between the various operational centres in the flood-fighting plan.

Flood-fighting measures for levee protection

On alluvial plains and in river deltas the most common form of flood protection taken by the local population has been the building of river levees or coastal dikes. Measures have been developed in many parts of the world to protect such embankments during flooding and storm surge. It is essential that those engaged in flood-fighting activities should be thoroughly familiar with the causes of embankment failure so that the best and most effective measures to meet local conditions can be chosen and used when an emergency arises.

Some examples of the measures that can be taken during flood-fighting operations to protect levees are given in the annex to this chapter. These examples show some of the traditional methods used in Japan for this purpose. They have been selected because they have proved to be effective over a long period of years; they are also inexpensive and of wide applicability in developing countries where bamboo, rice bags and logs are available locally.

The importance of using the most suitable and effective methods of protecting levees against the causes of collapse such as overflow, seepage and scouring cannot be overrated. Local conditions will play a dominant role in the choice made. It is also vitally important that the methods used can be executed with reliability even at night or under storm conditions.

APPENDIX

EXAMPLE OF LEVEE PROTECTION WORKS USED IN JAPAN

(1) Straw-mat spreading (Omote-mushiro-bari)

Purpose: To prevent sloughing of embankment and water seepage.

Method: Depending on the size of rupture of the slope face, 9, 12, or 15 sheets of matting are stitched together with rope; ribs of bamboos are coarsely woven through laterally at 90 cm intervals. Sandbags are attached to the lower end of the sheet as weights, the sheet is rolled around the weight and gradually unrolled from the top with rope, adding stitches where necessary. More sandbag weights are then loaded on the sheet to prevent flapping and the sheet is affixed.

Persons	*Materials*			*Tools*	
	Item	*Shape and size*	*No.*	*Item*	*No.*
10	Straw mat	1.8 m × 0.9 m	9	Wooden needles	Adequate number
	Bamboo	Circumference: 9 cm Length. 3.5 m	10	Mallet	1
	Wooden pipe	End diameter: 9 cm Length: 1.2 m	3		
	Two-ply rope	Length: 3 m	15		
		Length: 4.5 m	2		
		Length: 8 m	2		
	Three-ply rope	Length: 20 m	4		

Remarks. – Mats are arranged three in a row and three abreast and bamboo ribs placed at 0.6 m intervals. Sandbag weights are attached to the lower end. Also, to prevent flapping, sandbag weights are loaded on the upstream end to hold down the sheet.

(2) Tripod stitching (Gotoku-nui)

Purpose: To prevent enlarging of cracks or ruptures on the land side of an embankment.

Method: Drive three or four bamboo poles deeply into the ground on both sides of the crack at 1 m intervals in the shape of a tripod or quadripod. The tops of the poles are tied together with a rope 1.2-1.5 m above the ground. On top of the knot a sandbag weight is loaded. If there is no turf at the crack, or if the embankment is weak, sandbags may be used to secure the bamboo pole feet. This method is more effective at the foot of a slope than on its face. It is also safer to place supporting piles at the foot of a slope.

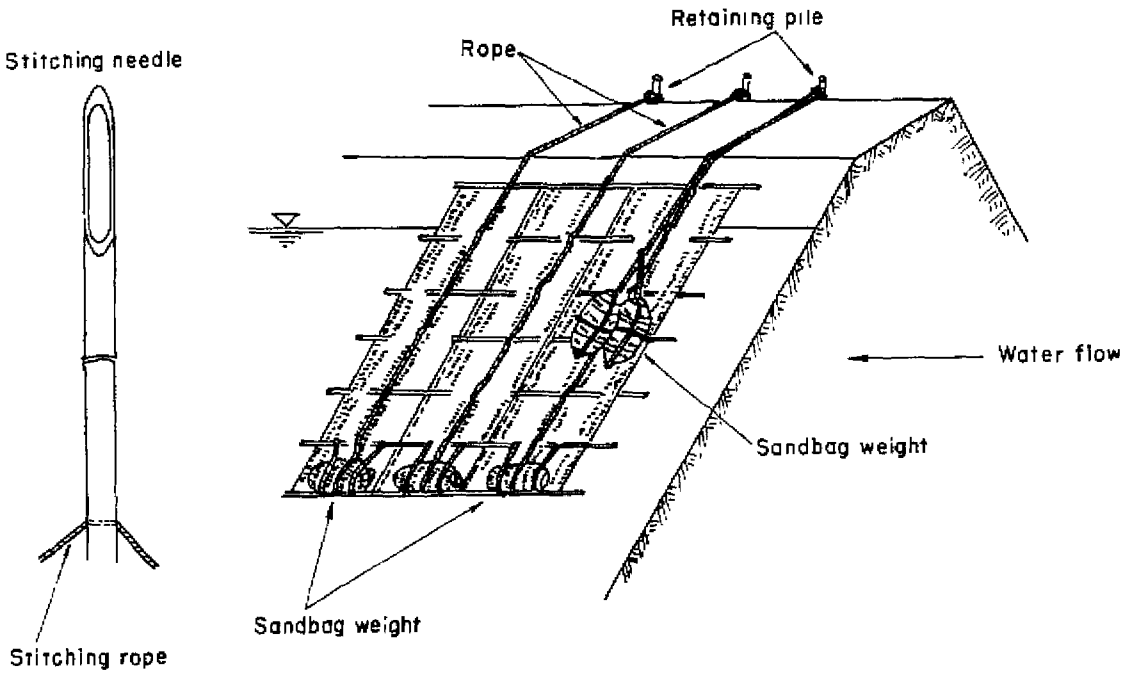

Figure 14 – Straw-mat spreading *(Omote-mushiro bari)*

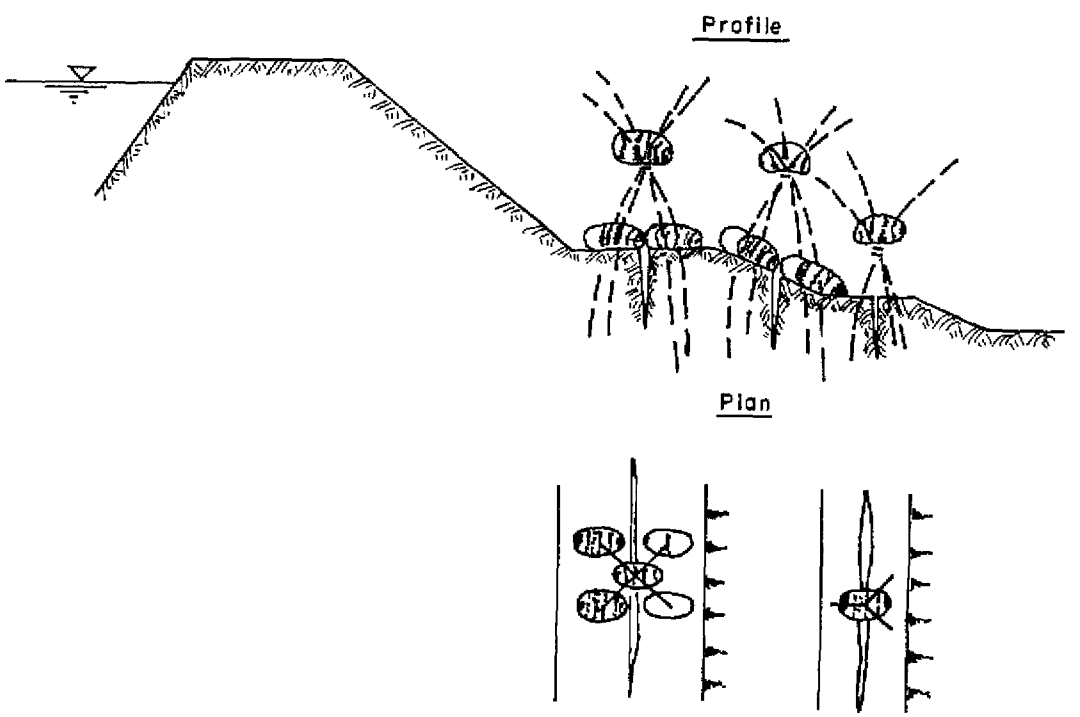

Figure 15 – Tripod stitching *(Gotoku-nui)*

Persons	*Materials*		
	Item	*Shape and size*	*No.*
10	Bamboo	Circumference: 18 cm, tapered	18
	Plastic bag		17
	Two-ply rope	Length: 3 m	51
		Length: 1.5 m	5

Remarks. – Quadripod. 3 places. Tripod: 2 places. Sandbags are used as foot weights for quadripods. Foot weights are not used for tripods but a sandbag weight is loaded. The distance between feet is about 1 m for both tripods and quadripods.

(3) **Folding** (Orikaeshi)

Purpose: To prevent rupture when cracks occur on the top of an embankment.

Method: Drive bamboo poles into the front and rear surface of the top of the embankment, placing sandbags at the roots as cushions. The poles are bent and the upper ends tied together at the middle of the embankment with rope. As the bent portion of bamboo is liable to break, bags are rolled up and inserted as cushions. To ensure tightness of the bamboos, sandbag weights are loaded on top.

Persons	*Materials*			*Tools*	
	Item	*Shape and size*	*No.*	*Item*	*No.*
10	Bamboo	Circumference: 15 cm, tapered	20	Axe	2
	Plastic bag		40		
	Two-ply rope	Length: 3 m	120		
		Length: 1.5 m	20		

Remarks. – Plant 10 bamboos at 1.5 m intervals, placing one cushion sandbag at the base of each and inserting bags at the bent part. Load sandbag weights at the joints.

(4) **Hooping** (Tsuki-no-wa)

Purpose: To store leaking water on the inner side and to reduce the pressure of seeping water.

Method: Stack sandbags around the leak at the foot of the slope in the shape of a hoop (radius 1.2 m-2.0 m). Absorb leaking water within this hoop and prepare channels for water discharge. The height of the stack should be just enough to reduce water pressure and, if the stack is more than three tiers of sandbags, retaining piles or fence piles are used. Mats are laid at the discharge channels and water is discharged through a conduit. Spaces between sandbags are earth-filled and sufficiently compacted to prevent leakage from any gaps.

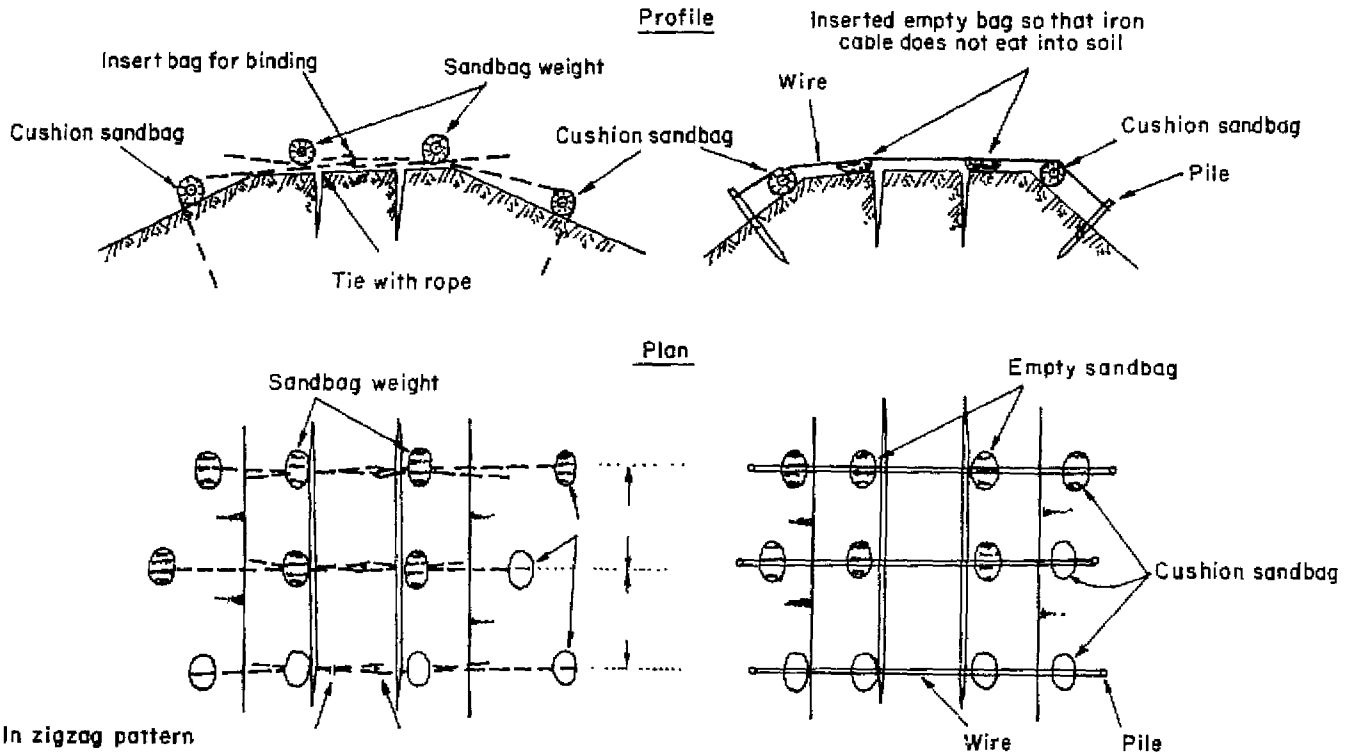

Figure 16 – Folding *(Orikaeshi)*

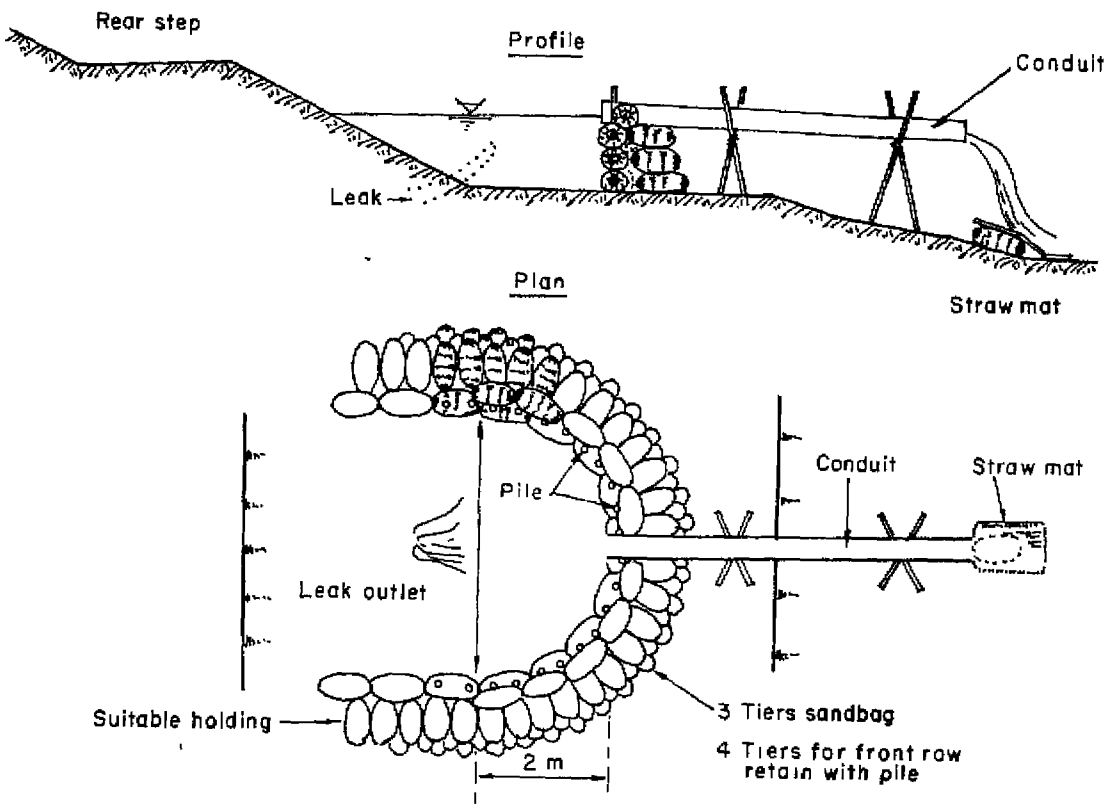

Figure 17 – Hooping *(Tsuki-no-wa)*

Persons	Materials			Tools	
	Item	Shape and size	No	Item	No.
25	Empty straw bag	With lid	140	Mallet	2
	Two-ply rope	Length: 3 m	405		
		Length: 1.5 m	2		
	Pile	Length: 1.5 m Diameter: 6 cm	32		
	Pile	Length: 1.8 m Diameter: 6 cm	4		
	Triangular conduit	20 cm × 30 cm × 200 cm	1		
	Straw mat	0.9 m × 1.8 m	2		

Remarks. – Three tiers of sandbags are stacked in a semi-circle at a radius of 1.8 m, with others added as required. For each bag, a bamboo pile of 1.5 m length and 15 cm circumference is planted as a retaining pile.

(5) **Sandbag stacking** (Tsumi-dohyo)

Purpose: To prevent water overflow.

Method: Stack sandbags to the required height on top of the embankment at about 0.5-1.0 m from the shoulder of the front slope, so that the stack will not be affected by any failure of the shoulder. If the stack is only one tier, the bags may be stacked lengthwise or widthwise. Earth is filled and compacted in between the bags, straw also being inserted to prevent leakage. For three-tier stacking, wooden or bamboo piles are planted for support.

Persons	Materials			Tools	
	Item	Shape and size	No.	Item	No.
20	Empty straw bag	With lid	120	Mallet	2
	Sandbag		33		
	Two-ply rope	Length: 3 m	526		
	Bamboo	Circumference: 9 cm, tapered	17		
	Two-ply rope	Length: 1 m	2		

Remarks. – For a length of 20 m with 2 tiers in front and 1 tier at the rear. Each bag is braced with 12 bamboo poles. Parallel stitching is employed for the top.

(6) **Sandbag stacking with piles** (Kuiuchi-tsumi-dohyo)

Purpose: To prevent failure of rear slope of embankment.

Method: Stack sandbag lengthwise along the slope and drive piles of about 2.5 m in length at 0.60 m intervals as support. A lateral beam of 5.0 m in length is affixed to the upper part of piles and props of 4.0 m are planted at 3.6 m intervals. In the middle portion of each prop, two retaining poles are driven, one at each side at an angle. At the root of the holding prop, pegs are driven two in a row as braces.

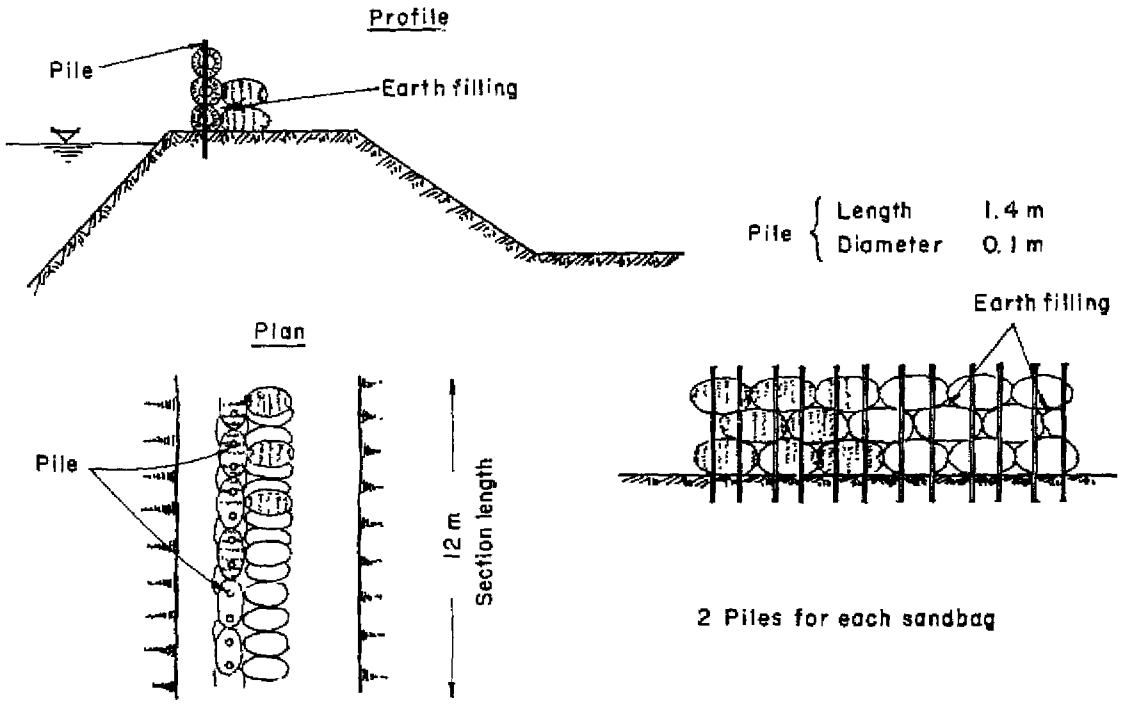

Figure 18 – Sandbag stacking *(Tsumi-dokyo)*

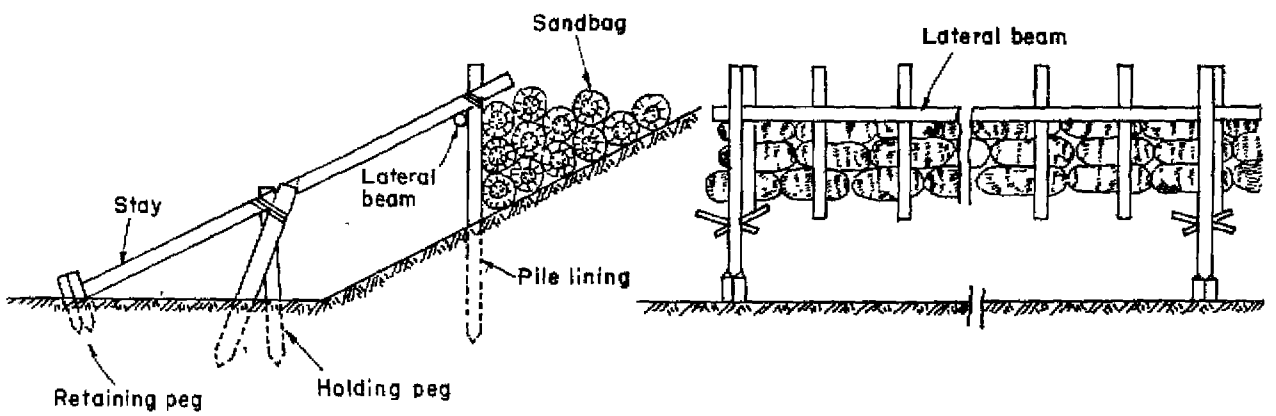

Figure 19 – Sandbag stacking with piles *(Kuiuchi-tsumi-dohyo)*

Persons	*Materials*			*Tools*	
	Item	*Shape and size*	*No.*	*Item*	*No.*
76	Empty straw bag	With lid	200	Mallet	
	Sandbags		900		
	Filling earth	Sandy soil (m^3)	30		
	Rope	10 mm (coils)	17		
	Logs*	ϕ 12 cm × 5.0 m	2.8		
		ϕ 12 cm × 4.0 m	3.8		
		ϕ 12 cm × 2.5 m	17.7		
		ϕ 12 cm × 1.5 m	7.6		
		ϕ 12 cm × 0.5 m	7.6		

* For each 10 m section.