2. Adaptability and characteristics

Historical sabo works have merits like less impact to scenery and environment, compared to the present construction works. Again, as historical sabo works uses the materials such as stone, woods etc. available in the local area, it is possible to reduce the construction cost if this technology is applied at present. On the other hand, as a result of the less durability or stability from the material and structural point of view, it has the shortcoming of having less safety against the sediment disaster in comparison to the present construction method.

However, there is a possibility of applying historical sabo works at present as low cost, environmental and scenery preservative construction method after improving its safety by the exploitation of its merits and improving of its shortcomings.

Here, regarding 1. characteristics of each construction method has been arranged in matrix diagram, using the survey sheets for historical sabo works, prepared based on the details provided in the literature. Characteristics, in detail refers to 4 major parts i.e. function, suitable installation place, materials used and durability. Regarding these parts, first, key words were picked up from the records in the survey sheets and classification was done for the matters described with different expressions but have same meaning. Then, all classified key words were arranged as ‘condition’ and matrix diagram have been made for the appropriate condition of each construction methods.

The construction types whose matrix charts have been prepared are as follows.

2-1 Hillside works
- 2-1-1 Small check dams
- 2-1-2 Earth retention works
- 2-1-3 Hillside slope cutting works
- 2-1-4 Hillside drainage channel works
- 2-1-5 Hillside benching works
- 2-1-6 Slope covering works
- 2-1-7 Plantation works
- 2-1-8 Maintenance works

2-2 Torrent control works
- 2-2-1 Dam works
- 2-2-2 Bank protection works
- 2-2-3 Channel consolidation works
- 2-2-4 Sub surface drainage works
- 2-2-5 Surface drainage works

2-1Hillside works

2-1-1 Small check dams

survey sheet no.			1	2	3	4	5	16	17	39	40
Type / condition			armoured retention	embankment retention	stone wall retention	stone box (gab ion) retention	well weir retention	arth retention/bac compaction works	hillside sto ne wall	earthen dam	stone dam
Function		pebble/stone retention/adjustment						○	○		○
		stream bank erosion prevention						○	○		
		stream bed gradient reduction							○		
		compaction of foot of the hill							○		
		stream bank collapse prevention							○		
		sediment flow blockade	○	○	○	○	○				
		hillside slope erosion prevention								○	○
Installation site	water flow	with water flow	○		○	○	○				○
		without water flow	○	○		○	○	○	○	○	○
	founda tion	sediment base	○	○		○		○		○	
		bed rock	○	○	○		○		○		○
	others	small stream condition		○							○
		depressed part at hillside		○						○	○
		narrow stream									○
		u/s with wide sedimentation area	○		○		○				
Necessary materials		pine wood		○							
		earth			○				○		○
		big aggregates			○	○					
		small aggregates									○
		mortar		○						○	
		grass				○					
		piles			○		○			○	
		clay				○					
		bamboo (gabion)						○			
		soil						○			
		brushwood			○					○	
durability		have temporary effect							○		○
		permanent effects can be expect	○			○	○	○			
		not durable		○							

2-1-2. Earth retention works

survey sheet no.			6	7	8	9	18
condition		Type	showelled up embankment wor	back pine retention	lined brush wood work	pile fence retention	base stone masonry work
Function		sediment movement blockade	○		○		
		sediment flow blockade	○	○		○	
		compaction of foot of the hill					○
Installation site	foundation	sediment base	○	○	○	○	○
		bed rock	○	○			
	others	mountain side of bare mountain	○				
		gentle slope of collapse mass				○	
		depressed part at hillside		○			
		hillside		○			
		foot of the hill		○			
		hillside of collapsed mountain			○	○	
		hillside with vertical rise					○
Necessary materials		sediment	○				
		long stone					○
		pine wood		○			
		pine brushwood		○			
		pine raw tree		○			
		small piles				○	
		bamboo splits				○	
		brushwood			○	○	
durability		good					○
		don't last long due to material decay		○	○	○	○
		possibility of washout or damage	○				

2-1-3. Hillside slope cutting works

survey sheet no.			19		
condition		Type	slope cutting works	embankment stone masonry	embankment kintted fence
Function		readjusting of slope condition		○	
		reduction of slope gradient		○	
		preparation of base of hillside works		○	
Installation site		unstable slope of hillside		○	
Necessary materials		stones		○	
		excavated soil from slope		○	○
		brushwood			○
durability		possibility of collapse is high if the slope excavation volume is high		○	

2-1-4. Hillside drainage channel works

survey sheet no.			20		21
Type / condition			water channel turfing work	water channel stone pitching	brushwood sub surface drainage
Function		prevention of erosion	○	○	○
		ground water drainage			○
Installation site	water flow	with water flow	○	○	
		without water flow			○
	foundation	sediment base	○		○
		bed rock		○	
	others	above impermeable layer			○
Necessary materials		grass	○		
		stone		○	○
		sediment			○
		pinewood pile			○
		brushwood			○
durability		good		○	
		weak in erosion by water flow	○		
		depends on water flow part material			○

2-1-5. Hillside terracing works

survey sheet no.		22	23	24		25	26	27	28	29	30
condition	Type	seedling works	plantation works	ence retention wit bundled straw	fence reten tion dam	stone maso nry works	fencing works	straw works	thatch works	stripe works	bundled brushwood
Function	hillside afforestation	○	○						○		○
	seedling growth promotion							○		○	
	sediment blockade		○						○		○
	sediment collapse prevention			○		○	○				
	water conservation capacity increase		○	○				○			
	foundation preparation for plantation		○								○
	erosion control				○	○	○				
	slope gradient reduction					○					
	foundation works for each slopes					○					
	hillside slope covering									○	
	soil formation at hillside									○	
Installation site	bare mountain with soil layer	○	○								
	places having deep surface soil									○	
	bare land at mountain parts							○			
	hillside								○		
	foot of the hill								○		
	outcropping of bed rocks					○					
	gentle slope						○	○		○	
	steep slope			○							○
	in between plantation works									○	
Necessary materials	grass stubs with roots	○									
	seedling growth promotion									○	
	grass		○								
	straw							○			
	fertilizer straw		○							○	○
	bundled straw (brushwood)			○	○						
	brushwood			○	○		○				
	bundled brushwood										○
	rooted thatch stubs								○	○	
	wooden piles			○	○		○				○
	broken stones					○					
durability	continued to the present after improvement	○	○	○	○					○	
	depends on the elongation of the root								○		
	permanent effects can be expected					○					
	does not last long due to material decay						○	○			○

2-1-6. Slope covering works

survey sheet no.		10	31	32	33	36
condition	Type	straw covering works	bundled straw net works	scattered straw	brushwood log works	mixture sowing work on slope
Function	hillside conservation	○				
	frost control	○				
	soil erosion control	○		○		
	promotion of self growth of grass	○		○		
	sediment blockade		○			
	impact on water conservation effect		○			
	improvement of slope at collapsed area				○	
	representation of plantation works				○	
	slope afforestation					○
Installation site	hillside slope					○
	gentle slope	○	○			
	collapsed area				○	
	bare land				○	
	rough types of soil		○			
	severely damaged by frost in winter			○		
Necessary materials	bamboo split	○	○			
	straw	○		○		○
	bundled straw		○			
	cut grasses			○		
	silver grass			○		
	brushwood				○	○
	wood				○	
	grass seeds					○
durability	does not last long due to material decay	○	○	○		
	continued to the present after improvement				○	○

2-1-7. Plantation works

survey sheet no.		11	12	13	14	15	34	35
condition	Type	nursary plantatio work on contour	grass plantation work on contour	scattered grass plant ation on contour	scattered pine retention work	sowing reten tion work	seedling plant ation work	actual sow ing work
Function	hilly area recovery	○						
	prevention of sediment flow						○	
	prevention of sediment movement		○					
	hillside afforestation		○	○			○	○
	bare mountain afforestation				○			
	large scale afforestation					○		
	protection from direct sun light						○	
	protection from drying						○	
	surface soil formation							○
Installation site	bare land with scarcity of trees	○					○	
	places requiring hillside afforestation		○					
	gentle slope of collapsed hills			○				
	bare mountain				○			
	mountain part - stream bank					○		
	gentle slope							○
	around each hillside works/dam works						○	
Necessary materials	seedling	○					○	
	grass		○	○				
	green pine				○			
	seeds of tree					○		
	seeds of grass							○
durability	easy to slide by freezing and thawing		○	○	○	○		
	easy to root						○	○
	difficult to root	○						

2-1-8. Maintenance works

survey sheet no.		37
condition	Type	supplementary plantation
Function	affrestation of existing construction sites	○
Installation site	existing construction site	○
Necessary materials	seedlings	○
	fertilizer straw	○

2-2 Torrent control works

2-2-1. Dam works

survey sheet no.			38	39	40	41	42	43	44	45
condition		Type	sand retention	earth dam	stone dam	soil con crete dam	raw wood dam	brushwood work dam	stone low dam	stone masonry check dam
Function		retention of pebbles, sediment	○	○	○	○	○		○	
		blockade of sediment	○							○
		prevention of sediment flow								○
		prevention of stream bed degradation		○	○	○	○		○	
		reduction of stream bed slope			○	○	○		○	
		compaction of foot of the hill			○	○	○			
		erosion control of the foot of the hill							○	
		prevention of collapse			○	○	○			
		reduction in water current				○				
		collapse of both banks						○		
		maintenance of pebelled stream bed						○		
		protection of bank protection/drainage/dam works							○	
Installation site	water flow	with water flow	○		○	○	○	○	○	○
		without water flow	○	○	○	○	○	○	○	○
	foundation	sediment base		○		○	○	○		
		bed rock	○		○	○	○		○	○
	others	degrading stream bed							○	
		short term erosion stream								
		depression part of hillside		○						
		narrow stream			○					
		sediment trapping place available at u/s			○					
		gentle slope						○		
		steep slope							○	
		below plantation works								
Necessary materials		small aggregate					○	○		
		large aggregate	○		○	○			○	○
		wood					○			
		brushwood						○		
		brushwood stubs								
		willow branch								
		grass		○						
		bundled brushwood						○		
		raw trees with branches and leaves								
		earthen dam	○							
		clay	○	○				○		
		Sikkui	○							
		mortar			○					
		concrete				○				
		boulder concrete								
		bamboo gabion								
		willow gabion								
		GI wire gabion								
durability		Does not last long as materials decay						○		
		Permanent effects can not be expected		○		○	○			
		permanent effects can be expected	○		○				○	○
		depends on materials								

46	47	48	49	50	78
turfing check dam	wooden low dam	knitted fence low dam	bundled brush wood low dam	gabion low dam	wet stone masonry/ bounder concrete dam
	○	○	○	○	○
○					
	○	○	○	○	○
	○	○	○	○	○
					○
	○	○	○	○	
					○
	○	○	○		
	○	○	○	○	○
○	○	○	○	○	○
○	○	○	○	○	○
	○				○
			○		
		○			
					○
					○
○					
					○
	○	○	○	○	
			○		
		○			
○					
	○				
					○
					○
					○
				○	
				○	
				○	
○		○	○		
	○				
					○
				○	

2-2-2. Bank protection works

condition		survey sheet no. / Type	55 stone pitching bank protection	56 stone box bank protection	57 stone wall bank protection	58 turfing work	59 alt. Stone and brushwood layer
Function		foot of the dam or stream bank protection	○	○	○	○	○
		maintenance of hillside construction object	○	○	○	○	○
		stream bed and bank erosion and deep cutting prevention					
		prevention of damage to bank protection					
		foundation of stone pitching					
		construction of stream bank					
		prevention of the bank erosion					
		stream bank compaction					
		stream bed stability					
		optional future stream bank construction					
		bank protection work construction					
		water supply					
		low dam					
		covering of bank protection works					
		blocking of damside collapsing places					
		repairment of river works					
Installation site	foundation	sediment base	○	○	○	○	○
		bed rock			○		○
	others	foot of dam, stream bank (near bank)	○	○	○		
		small stream					
		stream bank					
		stream bed					
		gulley of hilly area					
		streams having piping					
		gentle slope					○
		gentle bank slope (10%)					○
		stream gradient lower than 1/100					
		small sediment discharge					
		have less stones					
		upper part of stone pitching, bank protection knitted fencing works				○	
		bank slope protection					
		eroded sites					
Necessary materials		big stone	○		○		○
		small stone			○		
		wood	○	○			
		cedar bark					
		grass				○	
		pitching material					
		bamboo					
		bamboo split				○	
		brushwood					
		bundled brushwood					
		bundled brushwood matress					
		branch of willow					○
		iron pile					
		iron wire					
		iron hook					
		concrete					
durability		Does not last long as materials decay	○	○		○	○
		possible for long use with corrosion control					
		depends on the material					
		increases through the combination with other type of construction					
		permanent effect is expected			○		

Terminology

1. Cut stone : dressed stonematerial
2. Broken stone : used in the small stone, filling of stone wall, foundation compaction etc.
3. Conical stone : dressed stone with square surface at one side; conical was commonly used as
4. Boulder : in narrow sense, angular field stone, in wide sense, all course field stones
5. Blinder gravel : filling the gap of boulders and big stones with gravel

60	61	62	63	64	65	66	67	68	69	70
itted bamboo fen	pile arranged	patching	stone throw	bundled/packed	J-ring	metallic	gabion (iron, bam	hanging brush	De monse	Kitamura soil
bank protection	fencing work	work	ing work	brushwood work	bank protection	bank protection	boo, brushwood)	wood layer	water cut-off	concrete matress
○	○	○		○				○		
○	○	○		○						
			○							
			○							
			○							
				○						
				○			○			
									○	
										○
					○					
						○				
						○	○			
						○				
							○			
							○			
								○		
○	○	○	○	○	○	○	○	○	○	○
		○	○			○	○		○	
		○	○			○				
○	○									
					○				○	
							○			○
				○						
		○								
○	○			○				○		
○	○									
								○		
							○			
							○			
			○						○	
							○			
○		○		○	○			○		
	○									
		○								
○							○			
	○				○		○			
								○		
				○						
○										
						○				
						○	○			
										○
						○				○
○	○	○		○	○			○		
						○				
							○			
										○
			○						○	

2-2-3. Channel consolidation works

survey sheet no.			51	52	53	54
condition		Type	stone bank protection work	brushwood bank protection work	stone work bed compaction work	brushwood work bed compaction work
Function		conservation of mountain area	○			
		prevention of foot of the hill collapse		○		
		reduction of stream bed gradient			○	
		river bed degradation control			○	○
Installation site	foundation	sediment base	○	○	○	○
		bed rock	○		○	
	others	foot of hill	○			
		collapsed area	○			
		gentle slope		○		○
		less stone availability				○
Necessary materials		stone	○		○	
		small stone	○	○		○
		pine wood				○
		wood			○	○
		brushwood		○		
		brushwood fence				○
		bundled brushwood		○		
		clay		○		
durability		permanent effect can be expected	○		○	
		can not last long due to material decay		○		○

2-2-4 Sub surface drainage works

survey sheet no.			71	72	73	74	
condition		Type	stone sub surface drain	stone sub surface drainage with water channe	brushwood sub surface drain	earthen sub surface drain	earthen pipe sub surface drain
Function		ground water drainage	○	○	○	○	○
		prevention of sediment erosion	○	○	○	○	○
Installation site		less stone availability			○		
		clayey land				○	○
		mountain area		○			
Necessary materials		straw	○	○			
			○	○			
		moss	○	○			
				○			
		flat rock		○			
		wood			○		
		brushwood			○		
		bundled brushwood			○		
		grass			○	○	○
		earthen pipe				○	○
durability		permanent effect can be expected					○
		can not last long due to material decay			○		
		cease of effect due to chocking	○	○		○	

2-2-5. Surface drainage works

survey sheet no.			75	76		77
condition		Type	flag stone water channel	turfing water channel	flat block water channel	brushwood covering work
Function		fast drainage of large water volum	○	○		
		covering of bare hillside			○	
Installation site	foundation	sediment base	○	○	○	○
		bed rock	○	○	○	○
	others	stream bed	○			
		water cut streams			○	
		bare hillside area				○
		steep - gentle slope	○			
		gentle slope		○		
		sediment transport		○		
		no sediment transportation			○	
		stone	○			
		wood	○			
		brushwood	○			
Necessary materials		laying grass		○		
		laying blocks			○	
		branch wood				○
		filler material				○
durability		permanent effect can be expected	○		○	
		has temporary effect		○		○

3. Important points to apply methods and facilities

As explained in the changes of the structure of sabo dam, design of present sabo dam is based on the object having durability and stability. . However, present sabo dam is an excellent structure based on the durability and stability. On the other hand, due to less durability and stability of historical sabo dams compared to the present method, some considerations become necessary in order to apply that construction method at present. However, it is reality that due to the application of natural materials as major materials and relatively small scale of construction, it has considered very important matters from scenery and environmental point of view, which is being lacked in present construction method. Again, Ministry of Construction, in the policy of main string environmental policy, has explained the necessity of environmental considerations during the maintenance of housing and social assets from now, with the expression ‘Environment brings internal objectivity in construction administration’ (Refer the following parts).

As a main hint to overcome such weak points, focusing at methods of historical sabo works (here, sabo dam) and arranging their characteristics, investigation was done based on those characteristics on the improvement points to use the methods of historical sabo works effectively.

Following major points can be considered as the important points on the application of historical sabo works.

3-1 Durability and stability of the structure
3-2 Characteristics of the installation place
3-3 Reason for the existence of historical sabo facilities at present

Concept of environmental policy on the formations of a country

(Creation and inheritance of the beautiful environment having space and wetness)

■With the cooperation between the human and in order to form the beautiful environment, which is graced by ‘space and wetness’ with abundance of pure water, green or open space and very rich in culture, maintenance of housing and social assets which is made of the regional characteristics and individuality is promoted.

(Preservation of the healthy environment)

■ Mitigation works like renaturalization etc. for the reduction of impact to the environment is done with the preservation of superior natural environment as far as possible. Again, in order to reduce the impact to the environment, energy saving, resources saving, recycling activities are promoted along with the promotion of the maintenance of roadside environment.

(Contribution to the global environment problems and promotion of international cooperation)

■ Regarding the environmental problem widening to the global scale by the cross country effects of damage, as well as the environmental problems of the developing countries which need the international matching that includes the advanced countries as well, positive correspondence is done including the international cooperation.

- Selected from the main string environmental policy, Ministry of Construction

3-1 Durability and stability of the structure

3-1-1 Durability

Focusing on the recorded item named durability in ‘Survey sheet on methods of historical sabo works’, arranged in chapter. following can be said regarding sabo dam.

- Durability of historical sabo dam has wide range, from a few years to up to present.
- Dams, using gravel (stone) have comparatively high durability.
- Dams, using wood have less durability.
- Durability increases with the devices of stone piling methods.

3-1-2 Stability

Observing the ‘Survey sheets on methods of historical sabo works’ arranged in chapter1 following can be said.

(Shortcomings)

- Most of the historical sabo dams have insufficient insertion under the ground, or due to the lack of front side protection works, chances of falling down is high as the foundation scouring possibility is high.
- As the historical sabo dam structures are made of the piling up of individual stones, chances of damage is very high during large scale flood or slope failure if the piling is not appropriately done.

(Merits)

- Dams with small scale of construction are comparatively durable and existing even at present.
- Most of the sabo dams of gravity arch system are comparatively existing even at resent.

3-2 Characteristics of the installation place

Observing the ‘Survey sheets on methods of historical sabo works’ arranged in chapter1. following can be said.

- It has been set at the bed rock part which are difficult to be scoured.
- It is still existing at the watersheds having relatively finer particle size.

- It has been installed at the watersheds where debris flows are less frequent or are of very small scale even though they are occurred.

3-3 Reasons for the existence of histrical sabo facilities at present

From the result of field survey on the historical sabo works existing at present, the reasons for the existence of those facilities, without falling down, even at present are supposed to be as follows.

1. Low scale of the facilities
   Scale (height) of most of the dams was equal or lower than 5m. When the scale of the facility is small, Strength of debris flow or flood or impact of pressure of sedimentation is less which is beneficial for the stability.

2. Gravity arch structure
   In order to distribute the strength of debris flow or flood or impact of pressure of sedimentation to the banks, most of the dams had gravity arch structure.

3. Installed at the places which are difficult to be scoured
   Due to the location of the dam at strong bed rock, downstream side becomes the place which shows the similar function as that of apron.

4. Formation of well deviced water flowing part
   Wings are avoided from hitting by flowing water or sediment by passing the water through strong bed rock, again by making the one side wing wall structure in such a way that water flow concentrates at the rocky central part, in order to prevent that part from damage and wearing.

5. Relatively steep downstream slope
   Most the downstream slopes are very steep i.e. having slope of about 1:0.2 – 0.5, which are beneficial to prevent wearing of the main dam at the downstream slope. In such cases, most of the cases have installations at the places where there are bed rocks having less scouring potential or installation of aprons.

4. Basic plan regarding the improvement of methods

When methods of historical sabo works is used as the base of the basic sabo works at present, it will be an object having weak points of low durability and low safety, as explained above, but at the same time, an object having less impact to natural scenery and less burden to the eco system. Again, most of the present construction method is superior in durability and stability but needs serious consideration on the impact to the scenery as well as eco system.

Due to the lack of stability and durability of historical sabo facilities when placed as unit structure, shortcomings of method of historical sabo works can be overcome by suitably applying the merits of each other through the combination of both historical and present sabo work methods in the small scale watershed or as an object of some regular sections. Such compound application of historical sabo works and present sabo methods can be thought as one of the skillful ways of applying historical sabo work methods at present.

Basic Plan: Compound application of historical and present sabo work methods

By properly arranging historical and present sabo work method, development of the sabo industry included with various contributions to the region, such as,

- Security of the safety
- Consideration to the environment
- Formation of excellent scenery

is done.

Merits of present sabo work methods: provide

- better durability
- better stability

around the origin of sediment production area and area having conservation objects.

Merits of historical sabo work methods: Less impact to the

- scenery of the surrounding natural environment
- burden to the ecosystem

when applied at relatively safer place.

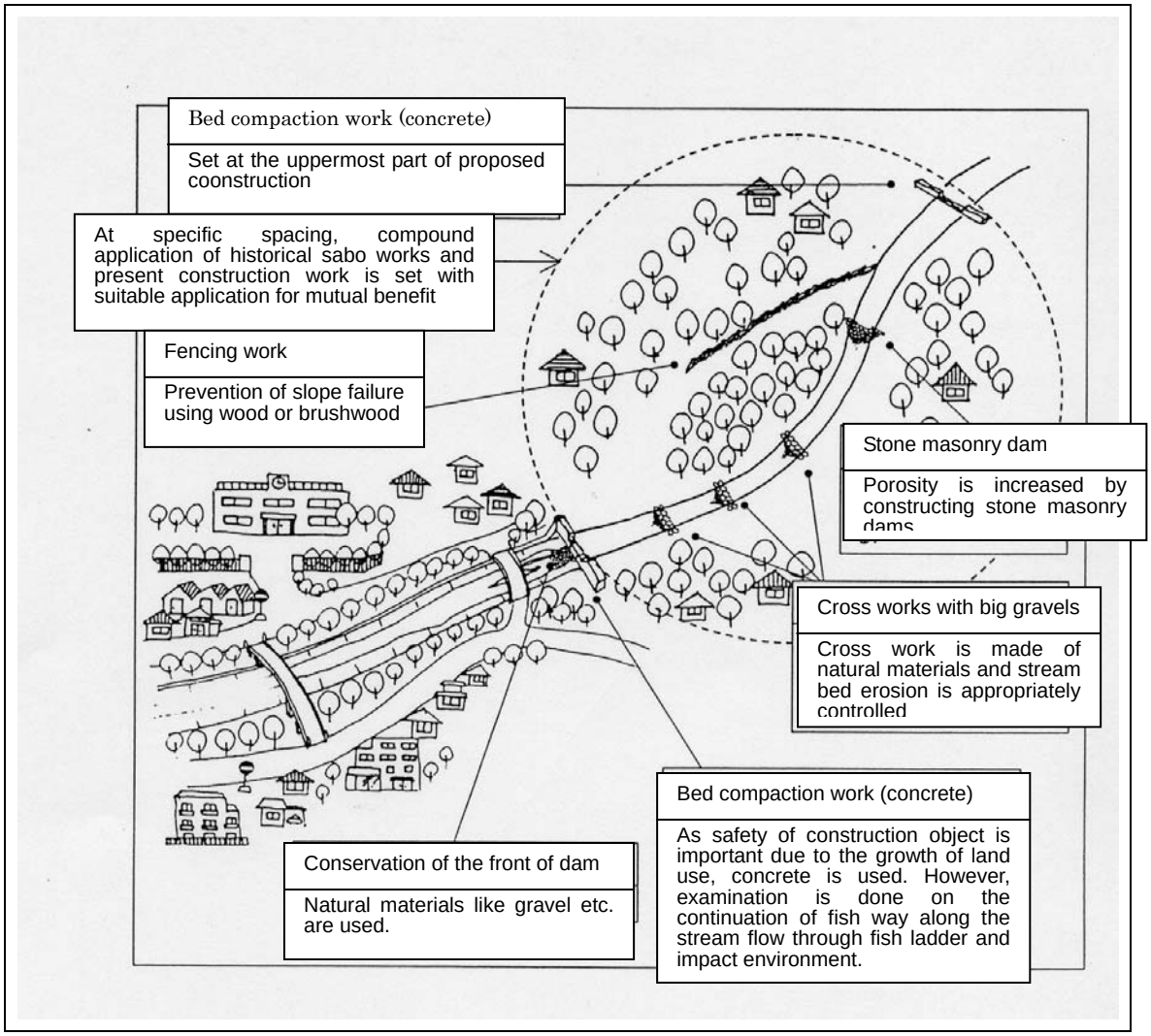


Figure 4.1 Image of the compound sabo work method with historical and present sabo work methods

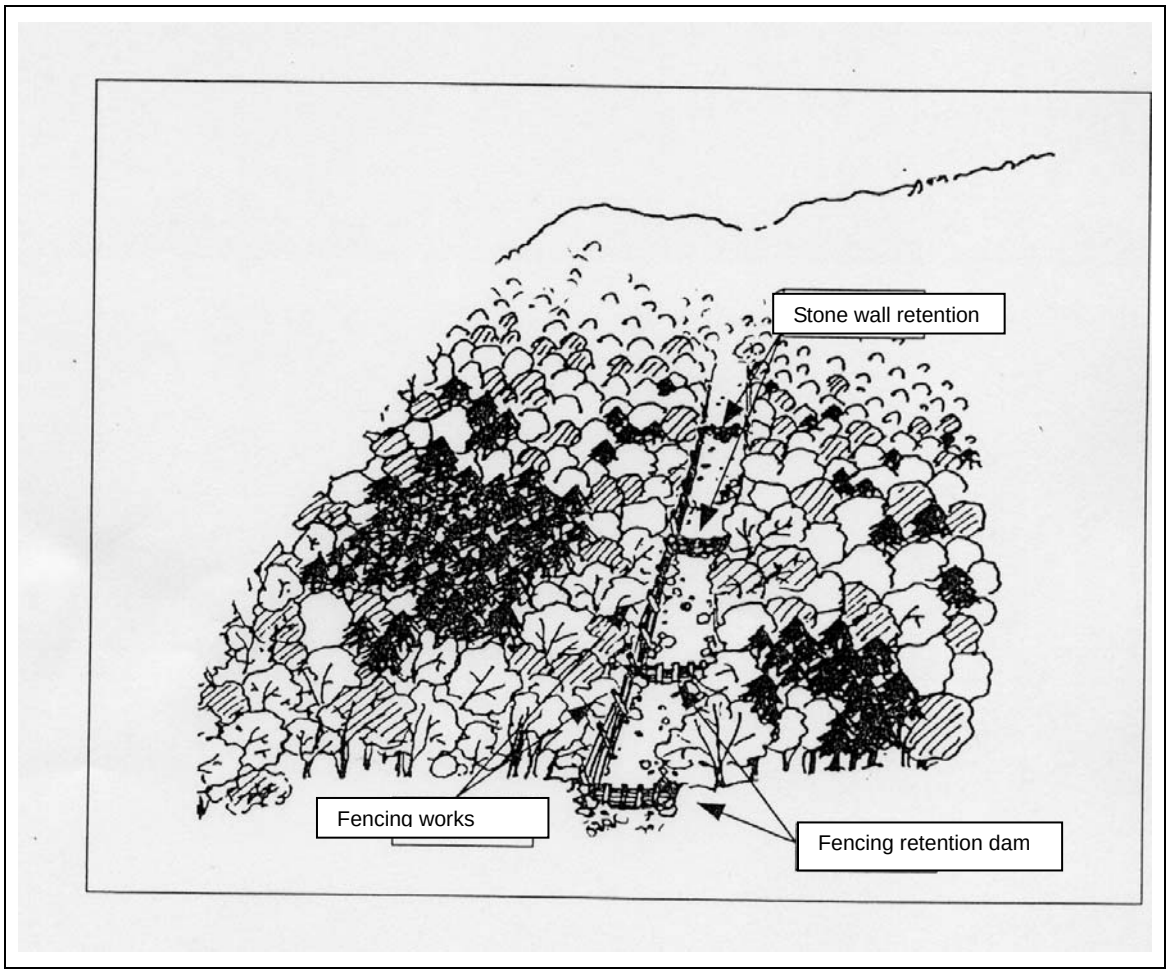


Figure 4.2 Image of the compound sabo work method with historical and present sabo work methods

5. Improvement of methods

Following can be said from the investigation of 'Important points and basic plans for the application of historical sabo works method', explained in 4.

Important points

- Historical sabo work methods are applied at the places, which can keep safety.
- Scale of the facility is made small.
- Important points on durability or safety increases with the improvement.

Basic Plan

- Compound application is done with present construction methods.

When historical sabo work methods are applied at present, as the basic plan to sue compound works with present construction methods, possible places for the application of historical sabo work methods are selected and each facilities are made of small scale as the initial application condition. Besides, improvement in durability and stability is important.

Basic Condition

- (Compound type of application is dome with historical sabo works and present construction works)
  : Historical sabo work methods and present construction methods are installed appropriately.

Initial conditions

i. Places suitable for historical sabo facilities are selected.
: Scale of sediment flow phenomenon is small.
(reduction of external load on construction)
: Easy availability of local materials (materials are easily prepared)

ii. Construction scale is made small
: Reduction of external forces such as flow force and soil pressure
(reduction of external load on construction)
: Due to manpower based construction (easiness in construction)

(Improvement of important points) = Improvement of historical sabo dam

1. Improvement to increase durability
2. Improvement to increase stability

5-1 Improvement to increase durability

In order to increase the durability, it is necessary to construct the structures and functions which can have maintenance for long period.

Due to the main application of natural materials such as stones and woods, the material strength degrades compared to concrete used at present. As a result, it is necessary to increase the durability of construction through the method which increases the strength of the materials, such as application of medicine in wood, use of secondary products, use of hard materials at the parts subjected to wearing and so on. Besides, in order to make a dry stone masonry structure, it is necessary to increase the durability by the construction of stronger parts such as using concrete or bolt or iron wires at connection parts, method of aggregate placing (relatively highly stable method such as bank valley stocking or boulder valley stocking, materials having easy stone processing) and so on.

Although the hard type of approaches like construction materials, structure etc are also necessary, it can be thought that soft types (check and repairing of the facility) of approaches are also necessary. It is necessary to have maintenance of the facilities along with the maintenance management plan by planning regular checking of the facility or checking of the facility after the flood, repairing of the damaged part or regular maintenance and so on.

(Constructive)

- Increase of the strength of materials : processing of natural materials or selection of the substitute materials.
- Increase of the strength of the structure: Reinforcement of the material connection parts.

(Maintainable approach)

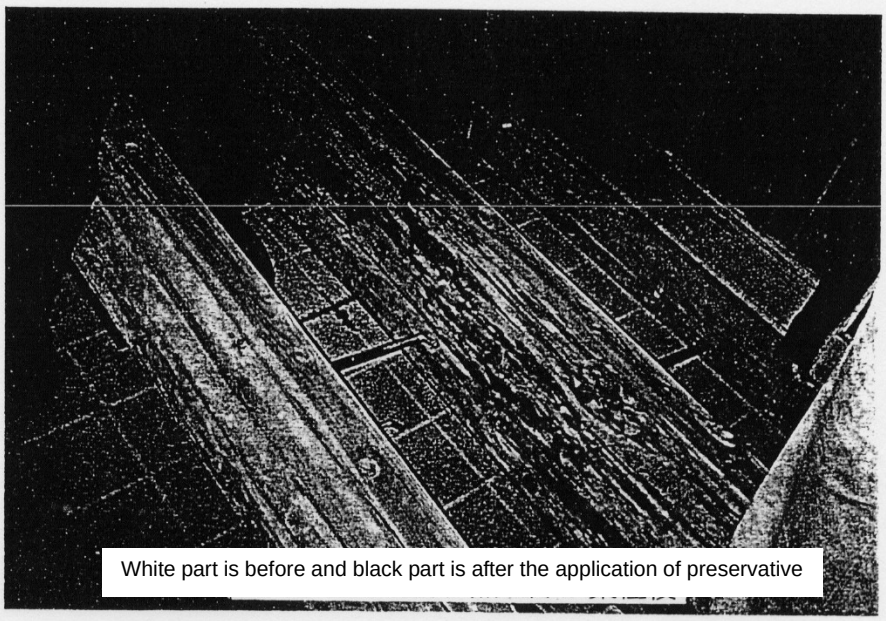
- Maintenance management planning: Maintenances such as checking or repairing.

Detailed points of improvements, investigated from the above view points are explained below.

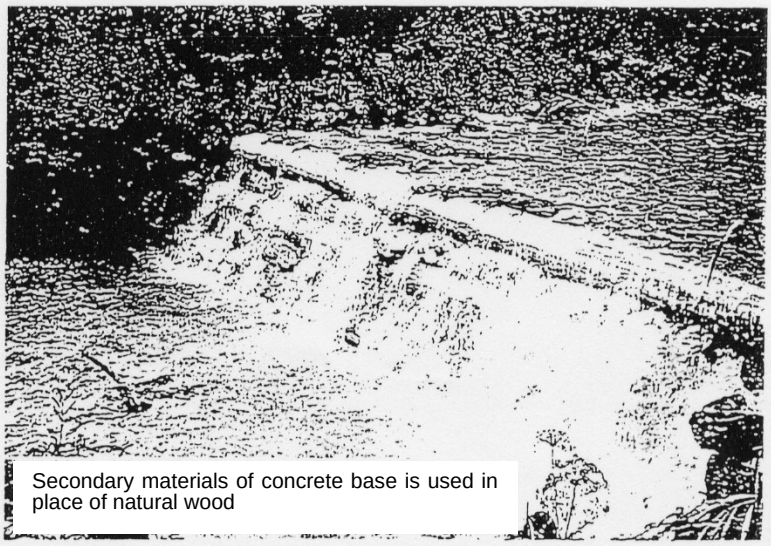
- In place of using natural materials as wood of wooden dam, strength of material is increased by using medically treated woods (refer table 4.4.1) or strong secondary products.
- In the connection part of the facilities made of stones or wood, structural strength is increased by inserting concrete or mortars at the back fills which are not perceivable to human eye.
- At the parts, subjected to wearing by water flow, strength is increased by using concrete or stone pitching works. Besides, Flow channels are fixed towards the bed rock in order to prevent the direct flow of water to the facilities.
- In case of stone masonry, strength is increased by stronger laying method or processing of the stones.
- According to the planning of maintenance management plan, regular checking or maintenance is done, which makes the preservation of the initial strength due to repairing.

In place of using natural materials as wood of wooden dam, strength of material is increased by using medically treated woods or strong secondary products.

(as detailed example)



White part is before and black part is after the application of preservative



Secondary materials of concrete base is used in place of natural wood

Table 5-1 Types of wood preservatives and their application method as well as durability years

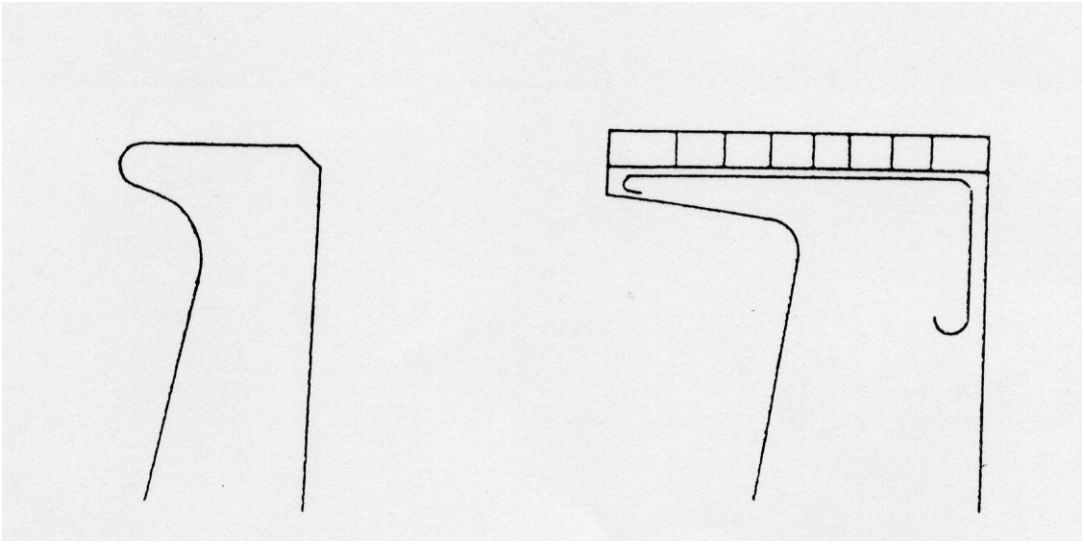
name of the preservative	characteristics	demerits	application method	absorbing quantity	use	durability years	suitability to construction materials
Creosote oil (JISK No.2470-1)	oily good penetrationcharacteristics has anti-decay effect	bad odour while handling very dirty anti-decay effect is less if GIS standard product is not used	application: 2 times immersion: 24 hours pouring in cold conditio pressurized pouring	10-20kg/m3 10-20kg/m3 50-100kg/m3 150-200kg/m3	outdoor wood outdoor wood outdoor wood outdoor wood electric pole (cedar)	8-10 years 8-10 years 15-20 years >20 years 20-30 years	Sufficient efefcts can be obtained when JIS standard products are used
CCA (JISK 1554) No. 1 A No. 1 B No. 2 chrome copper-arsenic compound	water soluble pressurized pouring less wash out characteristics high anti-decay and anti-insect effect no preservative odour possible to apply on the surface	special device is necessary for the pressurized pouring	Pressurized pouring JIS9002	12kg/m3 12kg/m3 9kg/m3	outdoor, indoor use general saw wood electric pole (cedar, larch)	>20 years >20 years >20 years >20 years	With the pouring by JIS9002method, the anti-decay and anti-insect effect is very high and is very suitable for civil engineering applications. CCA no.1B has good stability of preservative.
application, spray, immersion use (sampreza -O- GR, Kisiramon etc.)	oily anti-decay, anti-insect effect is easily obtained due to the easy immersion inside the wood	solvent have inflammability	application: 2times	200g/m2	outdoor, indoor use general saw wood	generally 2-3 time of the untreated materials	In case of civil engineering materials, anti-decay and anti-insect effects are easily obtained only by application. Specially, Sanpureza-0-GR has excellent infiltration capacity which make deep infiltration of preservative inside the wood and gives high anti-decay effect.
Pektaquanyu-BM	water soluble pressurized pouring has 3-4 times anti-bug, anti-decay effects than the untreated ones preservative is color and odour less BM treated wood remains same as the original wood has splitting prevention effect application: ok, BM trated wood: burning OK	special equipment is necessary for pressurized pouring	Pressurized pouring JIS9002	pouring quantity log wood: >300kg/m3 (larch, pine: >150kg/m saw wood: >300kg/m3	outdoor and indoor use general saw wood log house, shaded room bench table, signal boards etc., used in the park general saw wood	3-4 times of untreated wood	Although slightly lower durability than CCA preservative, but has sufficient anti-decay effect and less pollution. Thereforewidely used.
Sampreza-0-GR (in-situ aplication)	oily, application, sprayed infiltration use can have anti-decay, anti-insect effect easily due to well penetration to the inner part of wood	solvent have inflammability	application: 2times	200g/m2	outdoor, indoor applicatio general saw wood	3-4 times of untreated wood	If preservatives of more than 1.03 specific gravity is applied on the wood used in civil engineering materials, the wash out due to rain and wind is reduced and permanent prevention of decay is possible
Sampreza-clean W Osmogreen	soluble in water, application, spared infiltration use has anti-decay, anti-insect effect in wood	Due to the dilution by water, cost i cheap, but washout possibility is high due to contact with water	application: 2 times	200g/m2	indoor use general saw wood	2-3 times of untreated wood	does not suit in civil engineering materials due to wash out effects by rain and wind. Sanpreza-cleanW has good infiltration

In the connection part of the facilities made of stones or wood, structural strength is increased by inserting concrete or mortars at the back fills, fixing by bolts and iron wires, anchors, iron rods and so on which are not perceivable to human eye.

(as detailed example)

At the parts, subjected to wearing by water flow, strength is increased by using concrete or stone pitching works. Besides, Flow channels are fixed towards the bed rock in order to prevent the direct flow of water to the facilities.

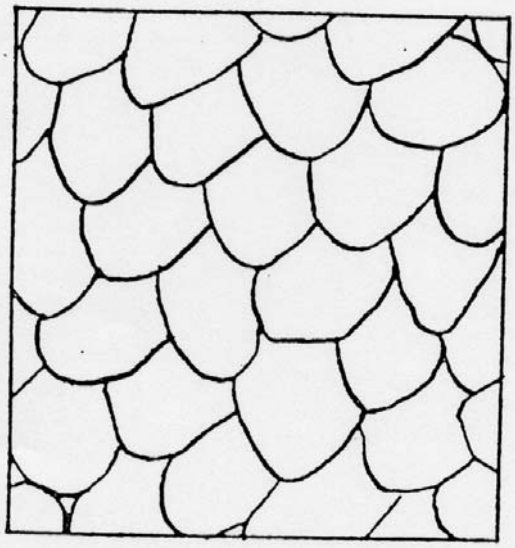
(as detailed example)



- In case of stone masonry, strength is increased by stronger laying method or processing of the stones.

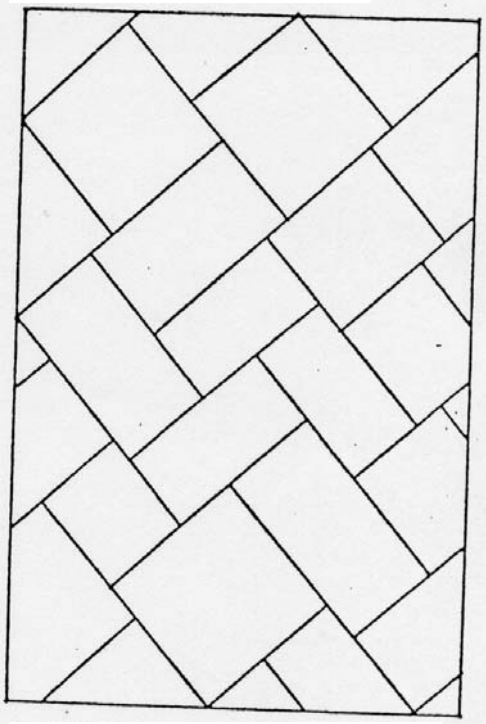
(As a detailed example)

Round stone valley compaction



If copper wire or backfilling is sufficiently done, it is stronger even without using concrete. However, strength is further increased due to the use of reinforced concrete, which does not collapse easily.

Dam protection valley compaction



This valley compaction is not very strong, is also economical

- According to the planning of maintenance management plan, regular checking or maintenance is done, which makes the preservation of the initial strength due to repairing.

(As a detailed example)

O O dam Maintenance management method DD river system DD river	. Check points . time . contents . .
. Maintenance points . Concerns to the local people	. Repairing points . Consideration to the scenery . prevention of lack in functioning

5-2. Improvements to increase stability

In order to increase the safety, it is necessary to do enhance construction in such a way that there will be no deformation in the facility due to the flow force or earth pressure.

Majority of the historical sabo facilities has the possibility of scouring due to insufficient insertion under the ground and insufficient compaction at the base, toppling due to the scouring of the foundation, damage due to large scale floods or collapses and so on. Therefore, it is necessary to increase the stability of the facility by securing the foundation part of the facility with the best construction method for the nature by using big stones or processed woods. Besides, in case of using natural materials like stones or woods, beside concrete, there is the possibility of decrease in stability due to self weight because of the lower weight of the facility. Hence, it is necessary to increase stability of the facility by fixing the facility to the foundation, using iron bars or anchors.

Although hard types of approach like securing of the foundation of the facility are also necessary, soft types of approach such as maintenance management side with checking and repairing of the facilities, as explained for the increase of durability, are also thought to be necessary. It is necessary to have maintenance of the facilities along with the maintenance management plan by planning regular checking of the facility or checking of the facility after the flood, repairing of the damaged part or regular maintenance and so on.

(Constructive approach)

Increase of the stability of foundation part

- pevention of foundation scouring due to the construction of front part preservation works with natural materials.

Increase of the stability due to gravity

- control of sliding due to the fixing of the facility with foundation
- single structuring of dry stone masonry with back filling of concrete

(Maintainable approach)

Maintenance management planning

- maintenances such as checking or repairing.

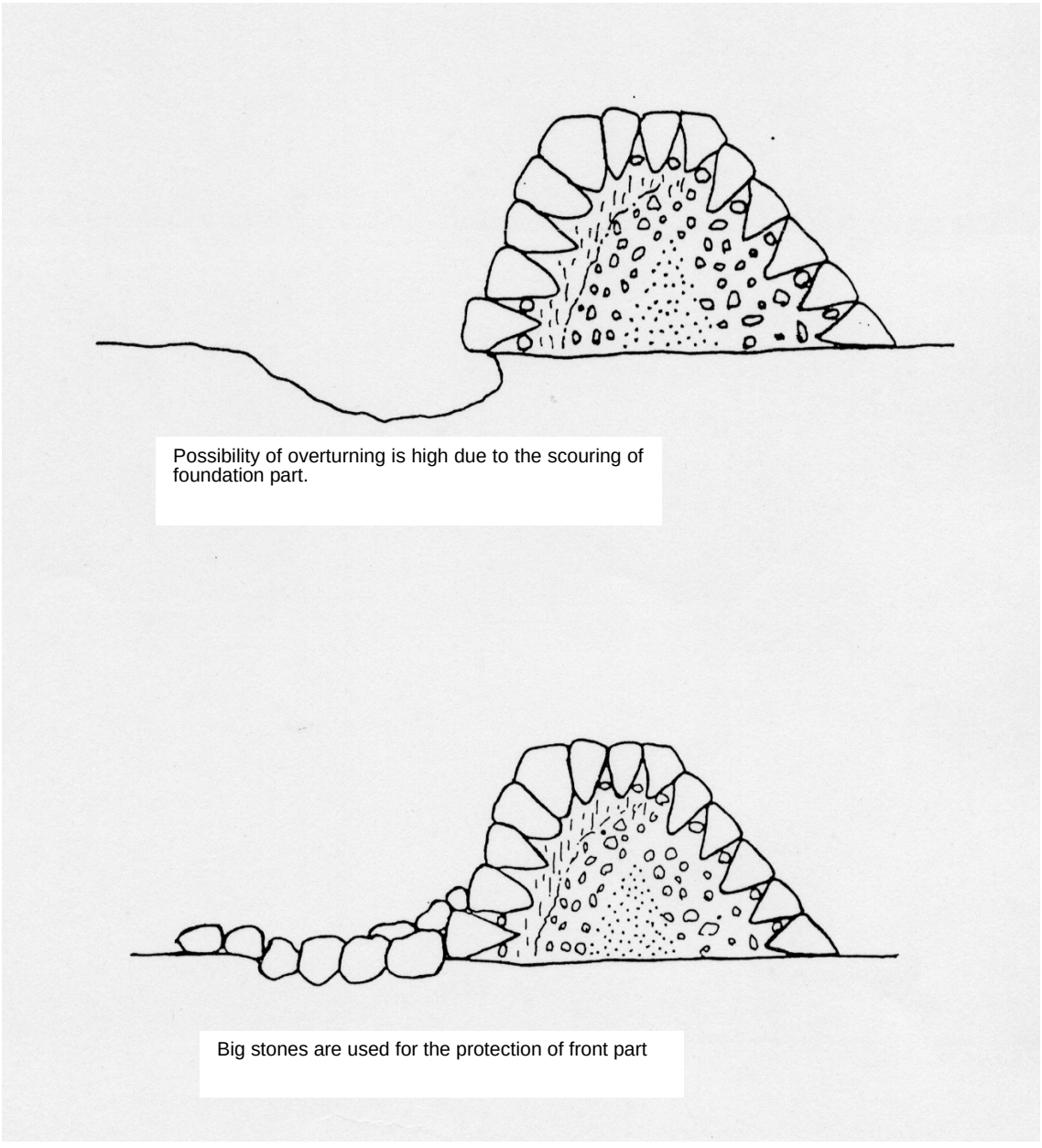
Detailed points of improvements, investigated from the above view points are explained below.

- In case of falling down or collapse of the structure due to the foundation scouring, scouring is controlled by the construction of front part preservation works such with natural materials like stones or processed woods.
- In case of decrease in stability due to the low self weight of the facility, facility is fixed to the foundation by using anchors or iron rods.
- According to the planning of maintenance management plan, regular checking or maintenance is done, which makes the preservation of the initial strength due to repairing.

(Due to the similar contents of investigations as explained in case of durability, please refer the earlier chapter)

- Scouring is controlled by the construction of front part preservation works such with natural materials like stones or processed woods.

(as detailed example)

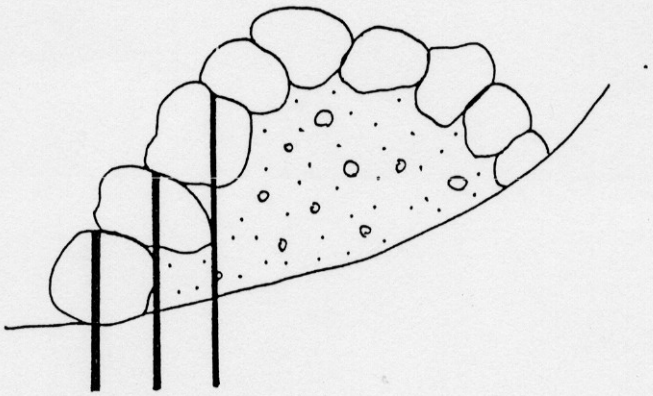


Possibility of overturning is high due to the scouring of foundation part.

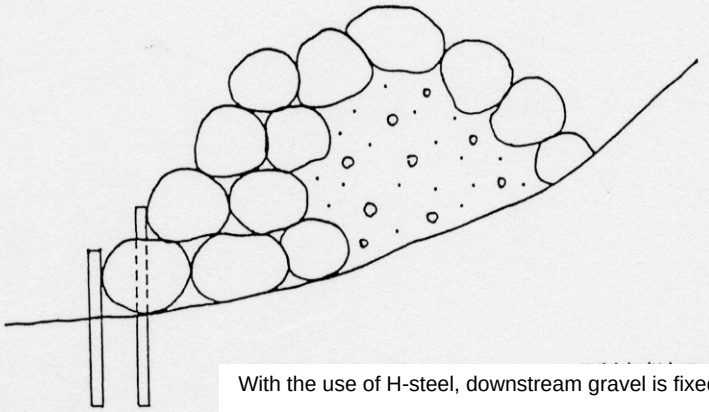
Big stones are used for the protection of front part

In case of decrease in stability due to the low self weight of the facility, facility is fixed to the foundation by using anchors or iron rods.

(as detailed example)



Stone and ground is fixed with reinforcement steel



With the use of H-steel, downstream gravel is fixed.