2.2 Sediment Quantity of the Sabo Plan

In sabo project, the design sediment production quantity that is produced within the projected catchment basin and is flowed down to the sub-control point is termed design sediment discharge quantity, of which the quantity controlled and arrested by sabo dam groups is termed proposed sediment control quantity and the quantity flowed down to downstream without having been controlled is termed excess run-off sediment quantity. In other words, excess run-off sediment quantity over the project = design sediment discharge quantity - proposed sediment control quantity.

2.2.1 The Design Sediment Production Quantity

The projected production sediment quantity includes newly collapsing sediment quantity, prospective expansion quantity of existing collaption, run-off to the river course out of the remaining sediment quantity and the sediment quantity flowing down by being subjected to the secondary erosion out of the sediment quantity which has been accumulated on the river-bed.

As the results of site invetigation and comparative reading of the aerial photgraphstaken in 1966 and 1976, annual average sediment run-off was calculated from annual average denudation rate of each class classified according to topography, geology and collapse degree, and from the data that the most heavy precipitation is concentrated in July 1972 out of monthly precipitation at Porac from 1968 to 1976, the maximum flood sediment discharge was calculated on an assumption that 80% quantity out of the total sediment discharge from 1966 to 1976 was produced in July 1972. The maximum flood run-off sediment quantity by catchments is as the table below.

Volume of sediment / Catchment	Area of catchment	Annual average volume of primary sediment	Sediment production volume per km^2	Primary sediment production during maximum flood	Sediment production volume per km^2
	km^2	m^3/yr	m^3/yr/km^2	m^3	m^3/km^2
Bucbuc River	9.5	262,000	28,000	2,091,000	220,000
Yangca River	4.6	6,000	1,000	50,000	11,000
Papatac River	3.2	9,000	3,000	74,000	23,000
Timbu River	4.7	51,000	11,000	407,000	87,000
Total	22.0	328,000	15,000	2,622,000	119,000

In general, the sediment quantity which is flowed down to the down-stream subjected to the secondary erosion of the sediment accumulated on the river-bed but is unstable sediment quantity is obtained from the river width and its erosion depth (refer to FIGURE II-1) or from the form of river-bed longitudinal section (refer to FIGURE II-2). In reference to the fact that the grain size of the river-bed constituting sediment is comparatively small, and that the form of river-bed longitudinal section (refer to FIGURE II-3) is generally flat, the secondary erosion of the river-bed in the maximum flood time will be up to 1.0 m in average in respect of the total plane of the river-bed, and quantity of each catchment is as the table below.

Sediment Q'ty / Name of catchment	Area of Catchment (km^2)	Sediment Q'ty due to secondary erosion (m^3)	Q'ty of Sediment erosion (m^3/km^2)
Bucbuc River	9.5	1,068,100	112,000
Yangca River	4.6	40,400	9,000
Papatac River	3.2	348,000	109,000
Tibu River	4.7	353,800	75,000
Total	22.0	1,810,300	305,000

2.2.2 <u>Design Sediment Discharge Quantity</u>

The design sediment discharge quantity is sediment quantity which deducted the controlled volume from design sediment production quantity by sedimentation and accumulation according to the riverbed longitudinal gradient and river width etc. until sediment reaches the sub-control point.

Although the design sediment production loses its stability due to rain and runs off to the river course and is then carried up to the sub-control point by the tractive force of flowing water during this while it is temporarily arrested and deposited on the river-bed due to change of the river-bed gradient, change of the water depth and etc. It was found from site survey that there is storage effect in the river course of main river and tributaries within the catchment, but it is assumed that there is no such effect in small tributary ravine of mountainside because of steepness in the ravine-bed gradient. On the other hand, as the results of further site surveys, it was learnt that there is the river-bed deposits which are considered to be from the flood in 1972, and from the river-bed cross-section (refer to FIGURE II-4) they are distributed on the present river-bed in the terrace form with a height of 1.5 m in average. Accordingly, assuming that there is river course control effect of 1.5 m thick in average all over the river course in the maximum flood, and the volume is calculated as shown in the TABLE below.

Name of catchment	Area of catchment (km^2)	River course control volume (m^3)	Volume controlled per km^2 (m^3/km^2)
Bucbuc River	9.5	1,563,300	165,000
Yangca River	4.6	29,850	7,000
Papatao River	3.2	499,500	156,000
Timbu River	4.7	489,450	104,000
Total	22.0	2,582,700	117,000

In addition, with regard to annual average run-off sediment quantity,, the sediment production quantity was calculated by multiplying the collapse discharge area with annual average denudation rate. Therefore, though production, run-off, and storage phenomena may take place annually, the amounts are averaged so that the production amount is regarded to be sediment amount disregarding river course adjustment.

In respect of the design sediment production quantity, its run-off factor shall be decided according to the collapsing condition, the river width and river longitudinal gradient as well as the planting condition. When the controlling quantity of the river course is considered supposing the factor is 1.0 from topography and geology and the entire sediment production quantity flow into the river course, the design sediment discharge quantity at the sub-control point is calculated as follows:

Design sediment discharge quantity

= Design sediment production quantity x run-off factor - River course control quantity

= (Mountainside ravine bank collapsing sediment production x run-off factor) + River-bed erosion sediment production quantity - River course control quantity

= 2,621,600 x 1.0 + 1,810,300 - 2,582,700 = 1,849,200 m^3

2.2.3 Proposed Sediment Control Quantity

The proposed sediment control quantity is the sediment quantity of 1,014,000 m^3 which is controlled and arrested by a group of sabo dams out of the entire design sediment discharge quantity.

2.2.4 Design Excess Run-off Sediment Quantity

The excess quantity is constituted of 835,000 m^3 (1,849,000 m^3 - 1,014,000 m^3), in quantity, of the sediment which ran-off to the downstream without having been controlled or adjusted by the upstream dams out of the projected run-off sediment quantity at the auxiliary reference point. For this excess quantity, the facility to temporarily adjust or check the sediment at each time of flood is necessary.

The design excess run-off sediment quantity is the remaining quantity of 835,000 m^3 (1,849,000 m^3 - 1,014,000 m^3) which flow down to the lower reach from the sub-control point without having been arrested or controlled by the upstream Sabo dams out of the design sediment discharge quantity. For this excess quantity, an appropriate facility is necessary to control and arrest temporarily at the lower reaches in flood time.

2.3 The Sabo Plan

2.3.1 Basic Plan

While the production sediment volume may be prerented through direct execution of work, from topography and geology, the inclined plane of mountainside may be fixed by way of tilted sediment of the Sabo dam and production can be controlled. However, in respect to facilities in the Papatac River catchment, there is no such effect because rocks on both bank are exposed, and consideration is made in respect to the Bucbuc River and Yangca River.

It is also planned that the run-off sediment control, besides that due to the river course, will be effected by way of easement of the river-bed gradient in tilted sediment area of the sabo dam and there will be such controlling as the storage effect at flood time, and the river course controlling in this section will be 0.

2.3.2 The Sediment Production Control Plan

It is a plan by which devastation of the production source will be recovered by way of preventing mountain collapsing, land slide, erosion of the river-bed, river banks, etc., and further through preventing occurence of new devastation, production of any harmful sediment will be prevented. Although from the engineering point, there are 2 mountainsides for direct execution of work, the main geology of devastation in the catchments is limited to the volcanic clastic rock deposits distribution areas (Bucbuc River, Timbu River), and these areas are mainly due to collapse of mountainsides by the river bank erosion and surface erosion of collapsing slopes. Since such topography and geology are considered to have little effect when they are examined in contrast to the surrounding protection objects, economic effects, etc., it is deemed appropriate to start the construction work, after the sediment treatment condition due to construction of the sabo dam was observed.

Accordingly, prevention of sediment production due to tilted sediment of the sabo dam is considered as FIGURE II-5 and, in the same way when the maximum flood run-off sediment volume was calculated, the value obtained by multiplying planned area of the buried section of collapse slope by prospective expansion depth is made to obtain the production prevented volume.

Production prevented volume

= The area buried by collapsed slope caused by tilted sediment of sabo dams collapsed slope's buried area x Depth x 8. (Magnification for bringing up ordinary annual average to the level of the worst flood ever experienced)

The prospective expansion depth was, from the annual average collapsing depth by devastation ranks, estimated to be 0.2 m. At the same time, it was determined from results of the site survey that the ones where such effects are expected are limited to the sabo dams having tilted sediment in the Bucbuc River and Yangc River catchments.

2.3.3 The Sediment Run-off Control Plan

It is a plan by which harmful run-off sediment is temporarily stored in the check facilities, and later control it to flow down safely to the down-stream, and at the same time the grain diameter of run-off sediment is also controlled.

The controlling effect is the difference of the planned retained sediment quantities between the projected tilted sediment gradient at the normal flood time and the projected sediment gradient at abnormal flood time, and it will be the controlled volume. Head is decreased by the effective height of the dam, sediment-covered river-bed is made higher so as to increase the width of the flow, river bed gradient decreases. However, the rate of original river bed gradient to sediment gradient fluctuates due to the quantity, grain diameter of the sediment from up-stream. The ratio of original river-bed gradient to tilted sediment gradient was obtained through tracing the terrace surface on the existing river-bed distributed near the dam by means of the river cross section drawing and at the same time finding the terrace gradient. As a result, it was estimated to be in a range between 1.0 and 3/4 (FIGURE II-7). In due consideration of safety, the range between 3/4 and 1/2 was taken up for designing. As projected tilted sediment gradient, with respect to the original river bed and as shown in Fig. V-6, No.2-A,B, No. 5 were set at 1/2, while No. 3, No. 4-A to F were set at 2/3. For sediment gradient at time of unusual flood, No. 2-A, B were set at 2/3, and No. 3, No. 4-A-F, and No. 5 were set are 3/4, so that tilted sediment gradient matching each dam were determined.

(Reference)

Name of dam	Original river bed gradient (1)	Terrace surface gradient in dam vicinity (2)	Terrace/ Original river bed (3)=(1)/(2)	Projected tilted sediment (4)	(5)=(4)/(1)	Gradient during unusual floods (6)	(7)=(6)/(1)
No.2-A " -B	1/70	1/70	1.0	1/140	1/2	1/105	2/3
No.3	1/50	1/62.5, 1/70	2/2.5, 2/3	1/75	2/3	1/67	3/4
No.4-A	1/35	1/56, 1/36	2/3.2, 1.0	1/53	2/3	1/47	3/4
No.4-B " -C	1/22	-	-	1/33	2/3	1/29.	3/4
" -D	1/22	-	-	1/33	2/3	1/29	3/4
" -E " -F	1/8	-	-	1/12	2/3	1/10	3/4
No.5	1/44.4	1/45	1.0	1/90	1/2	1/60	3/4

2.4 The Sabo Facilities Plan

2.4.1 Basic Policy

In order to arrange both the sediment production volume and the rivercourse sediment volume and treat this, are the methods of establishing the Sabo facilities by direct execution of work, such as prevention of unstable sediment by mountainside work, ground sill work, fixing to mountain foot due to tilted sediment of the check dam, and the indirect one by which the controlling effect due to stored sediment of the Sabo dam is considered.

In the catchments, under study by considering control by the sabo dam, the direct or indirect effect of fixing to mountain foot and the controlling effect of the river course itself, the facilities plan was established. In respect to the stored sediment volume, the annual average run-off sediment volume will be made the object.

Annual average sediment volume shall be the object of storage sediment. Concerning 3,330,000 m^3 of Sabo dam tilted sediment quantity, it was decided that the sediment shall be flowed into the fan-shape sediment storage pond for the ten years which will be spent for completion of the sabo facilities and after completion of conservancy of the river. As the capacity is almost equivalent to total quantity for ten years of annual average sediment quantity for 304,000 m^3 the pond shall be used for this purpose.

There are comparatively few desirable Sabo dam sites and they are limited to No. 28 + 800 - No. 32 + 000 around 2km downstream of the Bucbuc River and No. 34 + 000 round 1.0 km up-stream from confluence of the Timbu River and Pasig River. While these locations are provided with exposed heads of agglometrate in the right and left banks, their basic river-bed portion has deep rock. (According to results of boring at Timbu dam site the deepest measured about 43 meters in depth.

Since installation of foundation of the Sabo dam to the rock with that deep river bed sediment accumulation is very difficult technically and economically, debris ground was made the foundation, but in this case the ground bearing force is limited. Accordingly, with the idea that the dam height has the limit of 15.0m, layout of the Sabo dam was considered.

Most of sediment production is limited to 2 catchments of the Buchuc River and Timbu River where volcanic rock depositions are distributed. Therefore, as many dams as possible were arranged on the Bucbuc River, and in respect to the remained quantity, the layout plan was established, so that it will be let flown down and treated in down-stream of the Papatac River.

2.4.2 The Sabo Facilities Layout Plan

The position of the Sabo dam should be selected at such location that is more effective and economical and provided with safety, both banks are made of rock, and in-between thereof is narrow, and also the river width of the up-stream section is so wide that stored sediment will be large.

However, the locations with such conditions are few, and they are limited to part of the Papatac River and down-stream section of the Timbu River. Accordingly, it was planned from results of the site survey and the longitudinal section gradient of the river-bed, that 10 units of Sabo dam shall be planned, and that the planned run-off sediment at the planned auxiliary control point by controlling respectively the maximum flood time run-off sediment quantity 1,849,200 m^3 in the case of no facilities, and 1,014,200 m^3 by planning the Sabo facilities.

Although the number of dams may be decreased by making No.3 dam a high dam, according to the reason given below, the aforementioned project was adopted.

When the height of No. 3 dam was made 40.0m, there would be obtained dam retained quantity of 302,000m^3 and controlled quantity for 120,000m^3 totalling 422,000m^3. This is almost equal in its effect to four sabo dams, namely, No. 4-A, No. 4-E, No. 4-F, and No. 3 dam. However, a large amount of cost will have to be spent as the river bed accumulation layer is very deep and foundation treatment is difficult, when high dam is made. In addition, first and second auxiliary dams become necessary due to high dams. This will increase the dam volume resulting in its being considerably uneconomical.

In respect to the Pasig River, which has the fan-shape head of a good amount sediment production, of 1,500m interval down-stream from the planned control point, since it has to secure safety of the Sabo facilities of up-stream catchment, and particularly this section goes through from the mountainous section to the level land section and further the river width becomes rapidly wide (50m - 200m), it is the section where the flow conditon is subjected to great change. Since there is also meandering of the center line of stream, the water balancing section is violent in collapsing and flowing-down sediment is large, from the river-bed's longitudinal section and height, 4 units of ground sill are arranged at 500m interval and between the ground sills each other spur dikes are arranged with 170m interval, so that fixing and stability of the river course will be realized. Thus at the stage of stabilization the section above high water are planted so that it will be covered with green.

In order to facilitate tilted sediment in the section corresponding to both the right and left bracket section and fix the river course, except for around confluences of tributaries, between the present condition of river width approx. 170m, spur dike works are arranged as follows:

(Shown in FIGURE II-8)

2.4.3 The Structure of Facilities

2.4.3 (1) Sabo dam

(1) No. 2 - A dam

Outline of catchment: The catchment area is 16.8 km^2 joining the Bucbuc River, Yangca River and Papatac River which have callapsible area at the upstream headwaters of the Pasig River. The river-bed gradiant around the dam; 1/70, the water course length; 10.0 km. In respect of the river width, parts of the Paparac River and Bucbuc River where agglomerate is exposed in both banks are comparatively narrow, and others are wider due to erosion of the both banks.

Condition of sediment run-off: Mainly due to the secondary erosion of pyroclastic deposits and terrace deposits, the annual average run-off sediment quantity is 277,000 m^3 at the dam site and the maximum flood run-off sediment quantity is approx. 1,607,000 m^3 without Sabo facility.

Sabo dam site: It is located at the site where the Paparac River flows from the narrow mountainous portion to the flat area. There is no suitable dam site at the down-stream reaches. There is one dam site at the upstream site, but that site seems dangerous due to erosion caused by progress of sediment reservation at the thin left abutment.

Structure: Dam height; 150 m, Design sediment deposits gradient; 1/140, Design sediment reserving quantity; 380,000 m^3, Control volume; 120,000 m^3, Design flood discharge 540 m^3/s.

(2) No. 2 - B

Outline of catchment: The catchment area; 15.7 km^2, the river-bed gradient around the dam 1/70, and review length is 8.6 km. In respect of others, it is the same as No. 2-A.

Condition of sediment run-off: The maximum flood run-off sediment quantity is approx. 1,645,000 m^3 without Sabo facility.

Sabo dam site: It is located at about 1.4 km upstream of No.2-A Sabo dam site, and is nearly the middle portion of the Papatac river having good exposed aggromerates at the both banks for dam site.

Structure: Dam height; 14.0mm, Design sediment deposits gradient; 1/140, Design sediment reserving quantity; 220,000 m^3, Control volume; 100,000 m^3, Design flood discharge 510 m^3/s.

(3) No. 3 - Dam

Outline of catchment: The catchment area is 14.3 km^2 joinning the Paparac River and Bucbuc River at the upper reaches of the Pasig-potrero River. The river-bed gradient around the dam is 1/50 and length is 7.4 km.

Condition of sediment run-off: The annual average run-off sediment quantity is approx. 1,607,000 m^3 without Sabo facility.

Sabo dam site: It is located at the up-stream site of the Paparac River which is approx. 200 m down-stream from confluence of the Bucbuc River and Yangca River. Since agglomerate is exposed in both banks, it is a good location. As terrace depositions reaching approx. 30 m in height are distributed in the up-stream sediment deposit area, it has a large effect to arrest and control them.

Structure: Dam height; 14.0 m, Design sediment deposits gradient; 1/75, Design sediment reserving quantity; 490,000 m^3, Control volume; 120,000 m^3, Arresting volume; 30,000 m^3, Design flood discharge; 480 m^3/s.

(4) No. 4 - A dam

Outline of catchment: The Bucbuc River which is the most up-stream portion of the Pasig River has plenty sites of collapsible area, and most of sediment of the Pasig River is discharged from here. The catchment area is 9.2 km^2, the riverbed gradient around the dam is 1/35, and the water course length is 6.1 km. In respect of the river-bed, it is narrow at the portion where agglomerate is exposed on both banks, but is generally wide at other places.

Condition of sediment run-off: The right bank side up-stream from the dam site is the largest sediment production source in the catchment, and it has the share of approx. 80% of the total. The annual average run-off sediment quantity is 258,000 m^3 and the maximum flood run-off sediment quantity is approx. 1,600,000 m^3.

Sabo dam site: It consists of the steep and narrow section where agglomerate is exposed in both banks. The up-stream portion of the dam where the present river-bed width is approx. 20.0 m, is wide in the river width, and accordingly it is a good location.

Structure: Dam height; 15.0 m, Design sediment deposits gradient; 1/33, Design sediment reserving volume; 270,000 m^3, Control volume; 80,000 m^3, Arresting volume; 30,000 m^3, Design flood discharge 250 m^3/s.

(5) No. 4 - B dam

Outline of catchment: The catchment area; 6.1 km^2, the present river-bed gradient: 1/22, the river course length 4.7 km.

Condition of sediment run-off: There is plenty quantity of sediment run-off as the site of No.4-A.

Sabo dam site: It is located at 1.4 km upstream from No.4-A dam, but there may be slight change of the dam site according to the detailed re-investigation at the site.

Structure: Dam height; 15.0 m, Design sediment deposits gradient; 1/33, Design sediment reserving quantity; 270,000 m^3, control volume; 80,000 m^3, Arresting volume; 30,000 m^3, Design floud discharge; 250 m^3/s.

(6) No. 4 - C dam

Outline of catchment: The catchment area; 5.2 km^2, the present riverbed gradient; 1/22, the river course length; 3.9 km.

Condition of sediment run-off: Sediment run-off quantity is plenty.

Sabo dam site: It is located at 0.8 km upstream from No. 4-B dam, but the dam site may be changed slightly according to the detailed re-investigation at the site.

Structure: Dam height; 15.0 m, Design sediment deposits gradient; 1/33, Design sediment reserving quantity; 200,000 m^3.

(7) No. 4 - D dam

Outline of catchment: The catchment area; 4.8 km^2, the present riverbed gradient; 1/22, the river course length; 4.0 km.

Condition of sediment run-off: Sediment run-off quantity is plenty.

Sabo dam site: It is located at 0.5 km upstream from No. 4-C dam and the site condition is the same as No. 4-B & C.

Structure: Dam height; 15.0 m, Design sediment deposits gradient; 1/33, Design sediment reserving quantity; 200,000 m^3, Control volume; 70,000 m^3, Arresting volume; 20,000 m^3, Design flood discharge; 210 m^3/s.

(8) No. 4 - E dam

Outline of catchment: The catchment area; 3.8 km^2, the present riverbed gradient; 1/8, the river course length; 2.8 km.

Condition of sediment run-off: Sediment run-off quantity is large.

Sabo dam site: It is located at 0.7 km upstream from No. 4-D dam, and the site condition is the same as No. 4-B & C.

Structure: Dam height; 15.0 m, Design sediment deposits gradient; 1/12, Design sediment reserving quantity; 150,000 m^3, Control volume; 50,000 m^3, Arresting volume; 20,000 m^3, Design flood discharge; 170 m^3/s.

(9) No. 4 - F dam

Outline of catchment: The catchment area; 3.0 km^2, the present riverbed gradient; 1/8, the river course length; 2.5 km.

Condition of sediment run-off: Sediment run-off quantity is large.

Sabo dam site: It is located at 0.35 km upstream of No. 4-E dam, and the site condition is as same as No. 4-B & C.

Structure: Dam height; 15.0 m, Design sediment deposits gradie gradient; 1/12, Design sediment reserving quantity; 150,000 m^3, Control volume; 50,000 m^3, Arresting volume; 20,000 m^3, Design flood discharge; 140 m^3/s.

(10) No. 5 - dam

Outline of catchment: The Timbu River is the left tributary of the Pasig Petrero River. Since its catchment area is 4.7 km^2, the river-bed gradient around the dam is 1/44.4, length of the waterway is 4.4 km, and the river width is wide in the mid-stream section, this provides a good pocket of the dam.

Condition of sediment run-off: The catchment up-stream the dam mainly consists of the secondary corrosion of volcanic clastic rock deposits and terrace deposits which have spread to the right and left banks. The annual average run-off sediment quantity at the dam site is 41,200 m^3. In respect to the maximum run-off sediment quantity is 329,600 m^3, the river course unstable sediment quantity is 293,800 m^3, the river course control quantity is 406,950 m^3 and the projected run-off sediment quantity is 216,450 m^3. The annual average run-off sediment quantity is 15.5% of the design run-off quantity at the sub-control point.

Outline of dam site: Suitable locations for the dam in the Timbu River catchment have two good places; namely the one around a fall of the most down-stream section and a narrow section approx. 1.0 km upstream from this. Since the former has terrace depositions which are subjected to the secondary corrosion, and is improper, therefore, the latter was decided as the dam site.

Since up-stream from the dam site is wide in the river width, and terrace of about 5.0 m in height spreads to the right side bank, and also volcanic clastic rock depositions and terrace depositions are distributed in its upstream. These have the share of most of run-off sediment production source in this catchment.

The dam site is a narrow section of 22.0 m in the river width, agglomerate is exposed in both banks, and the right bank side is in the rock block form, and further welded tuff is exposed in the right bank, so it is only suitable dam site within this catchment.

Agglomerate of the left bank side is comparatively hard and it is almost vertically stood up from the river-bed. Rock block section of the right bank side is similarly agglomerate, and ravine portion of its right bank is covered with sediment. The right bank of ravine is agglomerate and is covered with sediment, and welded tuff which mounted on this as a foundation is extended upstream line of the dam and is devided by fault ravine at around the cross-section.

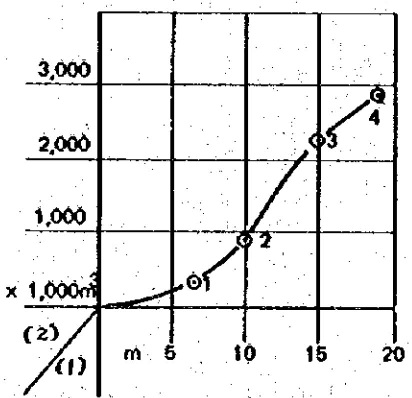
Examination on the dam overflow portion: According to topography and geology of the dam site, as it was required to investigate whether the dam overflow is to be provided at the present river portion or at the site of right bank side ravine, the site investigation was made and it was revealed that, as a result of it, when the overflow is provided at the latter site, the river course will be changed partially and the dam at the present river course shall be non-overflow type. In this case, the main dam and sub-dam can be constructed on the rock foundation which has enough bearing strength, and height of dam may be heighten to some extent and there will be no problems on the dam structure, however, to decide the structure of non-overflow portion, the problems of bearing strength of foundation and scoring at the downstream site shall be solved. Furthermore, if the overflow width is planned about 22 m as nearly same as the present river course, excavation volume at the right bank calculated from the plan, longitudinal and cross section of the site is estimated at a huge volume, and some appropriate protection work for the cut slope will be required.

On the contrary, when the overflow is provided at the portion of present river course, the layout is adequate from a viewpoint topography and river condition at present and after completion, and is natural shape against river flow. As to the dam structure, it is the same condition as the aforementioned non-overflow portion, therefore, the overflow was decided to the latter case after scruting the both cases. In this case, the reverse L-letter type small ridge which ranges from the right bank agglomerate block to the right bank welded tuff is located at comparatively high elevation, so the possibility to use as a part of dam right bank abutment and to substitute for the retaining wall of non-overflow portion in the revine was investigated, but the result revealed the impossibility due to future anticipation for flow out of alluvial layer which composes the small ridge.

Dam height: The dam foundation, because the river-bed deposit depth is more than 30 m, and from economical point of view, is the floating foundation, and accordingly 15.0 m is presumed to be the limit for dam height.

Design sediment deposit gradient: Since the grain diameter of the river-bed deposit at around the dam and that of upstream production sediment are comparatively small, the present river-bed gradient 1/44.4 x 1/2 makes the design sediment deposit gradient, that is, 1/90.

Relation between design sediment deposit quantity and dam height:



No.	(1) m	(2) m³
1	7	390,000
2	10	900,000
3	15	2,270,000
4	19	2,950,000

(1) Dam height above riverbed (2) Sediment deposit volume

The above figures show the volume of sediment deposit in cases of dam height is 7 m, 10 m, 15 m and 20 m respectively, and in case of dam height is between 10 m and 15 m, it shows high efficiency of sediment deposition.

Proposed sediment control quantity: Referring to the terrace plane longitudinal and cross sectional gradient of the present river condition, the sediment deposit gradient at abnormal flood time was determined.

River cross-section survey Station
No. 0 + 400 Terrace plane elevation EL275.00

River cross-section survey Station
No. 0 + 600 Terrace plane elevation EL279.00
Terrace plane gradient (279.50 - 275.50)/200 = 1/45

Since it is roughly the same as the present river-bed gradient, so taking the safety side, multiply 3/4 to this and make it 1/75.

The proposed sediment control quantity is 267,000 m³.

<u>Design flood discharge</u>: Since there is the experiment formula in the philippines, this was referred to, and the specific run-off was made 44.1 $m^3/sec/km^2$ and further the design flood discharge was made 190 m^3/sec so that the already decided design flow will conformity with 900 m^3/sec at the Mancatian Bridge.

<u>Determination of the overflow cross-section</u>: The run-off quantity from the overflow section is calculated considing that the upstream of dam is in the water resered condition and ignoring the approach velocity. The over-flow water depth is 8.2 m. The overflow width is calculated as 20.0 m which is similar to the river width of present condition.

$$Q = \frac{2}{3} \cdot H \cdot \quad 2 \cdot g \cdot H \cdot Bu$$

where:

= Flow coefficient 0.6

H = Over-flow water depth 3.2 m

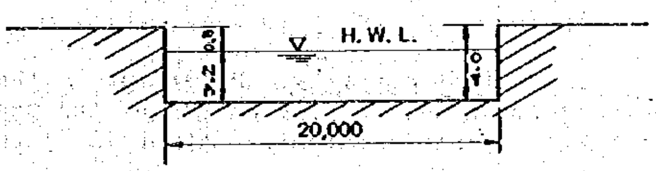
Bu = Overflow width 20.0 m

Q = Run-off quantity m^3/sec

$$Q = \frac{2}{3} \times 0.6 \times 3.2 \quad 2 \times 9.8 \times 3.2 \times 20$$

$$= 202$$

Though the design flood discharge of 190 m^3/sec is able to flow down with the over-flow water depth 3.2 m, adding the allowance height of 0.8 m, the overflow cross-section is determined with depth of 4.0 m as the following figure.



<u>Determination of main dam cross-section</u>:

Design conditions:

Over-flow water depth; 3.2 m

Crest width; 2.0 m

Down-stream slope; 1 : 0.2

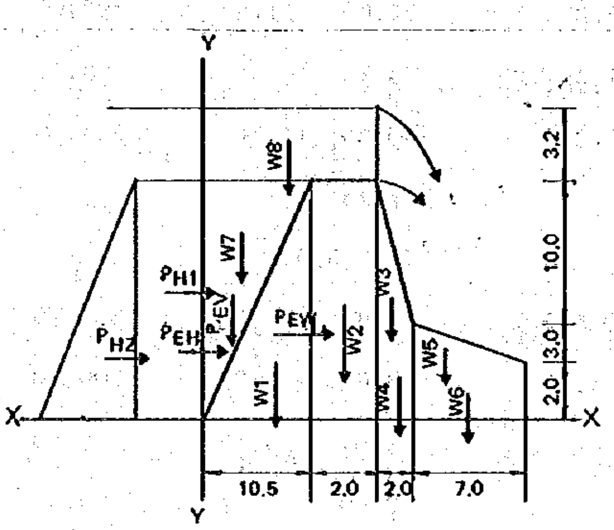
Dam unit volume weight; 2.2 t/m^3

Up-stream reserved water unit volume weight; 1.2 t/m^3

Seismic coefficient; 0.12

Upstream slope; 1 : 0.7

Assuming as above, and by adding footing 7.0 m in length to the down-stream toe of dam, safety is examined.



Horizontal component force

	Force		Arm	Moment
P_H	3.2x15.0x1.2	57.6	7.5	432.0
PH_2	15.0x15.0x1/2x1.2	135.0	5.0	675.0
P_{EW}		40.5	5.04	203.9
P_{EH}		15.77	7.33	115.59
	Total	248.87		1,426.49

$y = 5.73$

Vertical component force

		Force	Arm (X)	Moment	Arm (Y)	Moment
W1	10.5x15.0x1/2x2.2	173.25	7.0	1,212.75	5.0	866.25
W2	2.0x15.0x2.2	66.00	11.5	759.00	7.5	495.00
W3	10.0x2.0x1/2x2.2	22.00	12.5+2/3	289.67	5+10/3	183.26
W4	2.0x5.0x2.2	22.00	13.50	297.00	2.5	55.00
W5	3.0x7.0x1/2x2.2	23.10	14.5+7.3	388.85	3.0	69.10
W6	2.0x7.0x2.2	30.80	14.5+3.5	554.40	1.0	30.80
	Total	337.15				1,699.41
		$y = 5.04$				
W7	10.5x15.0x1/2x1.2	94.5	3.5	330.75		
W8	12.5x3.2x1.2	48.0	6.25	300.00		
PEV		11.04	5.13	56.63		
	Total	490.69		4,189.05		
		$x_1 = 8.53$				

Dynamic water pressure due to seismic force

$Pd = \alpha cm/2. \; Wo. \; kd \; H^2 \sec\theta$

α = 1.45 Coefficient when full dynamic water pressure is calculated

Cm = 0.48 Coefficient when $\theta = 35^o$

Wo = 1.2 Reserved water unit volume weight

Kd = 0.12 Seismic coefficient

H = (182., 3.2) Difference between full water depth and over-flow water depth

θ = 35^o Difference between vertical plane and upstream slope plane

Pd = $1.45 \times 0.48/2 \times 1.2 \times 0.12 \times (18.2^2 - 3.2^2) \times 1.22$

= 19.26

Horizontal component force of full dynamic water pressure

$19.26 \times \cos\theta = 15.77$

Vertical component force of full dynamic water pressure

$19.26 \times \sin\theta = 11.04$

Acting point of full dynamic water pressure

$hd = \beta H$

$\beta =$ 0.403 Coefficient at the time of full water depth

$H =$ 18.2 Full water depth

$hd = 0.403 \times 18.2$

$= 7.33$

Acting point of vertical component force

$7.33 \times \tan\theta = 5.13$

Position of acting point of resultant force

$X_2 : 5.73 = 248.87 : 490.69$

$X_2 = 2.90$

$X_1 + X_2 = 8.53 + 2.90 = 11.43$

Eccentric distance

$e = \frac{B}{2} \sim 11.43 = 21.5/2 \sim 11.43$

$= 0.68$

Down-stream end pressure

$P_1 = \frac{\Sigma V}{B}(1 + \frac{6.8}{B})$

$= 22.8(1 + 0.18)$

$= 26.9$

Upstream end pressure

$P_2 = 22.8 \times 0.82$

$= 18.6$

While the compressive force is 26.9 t/m^2 at the downstream end and 18.6 t/m^2 at the upstream end, ground bearing strength shall be improved up to 20.0 of N value at the depth of 5.0 m, as an indispensable condition, by an appropriate method because N value at the place of 5.0 m depth from the riverbed is 6.0 to 10.0. As a ground improvement means, N value can be improved by steel sheet pilling work at the upstream site of the dam foundation to intercep seepage water, and moreover, when compaction by the bulldozer is carried out, an effect will further be increased.

f = Coefficient of friction 0.7

ΣH = Horizontal component force 248.87

ΣV = Vertical component force 490.69

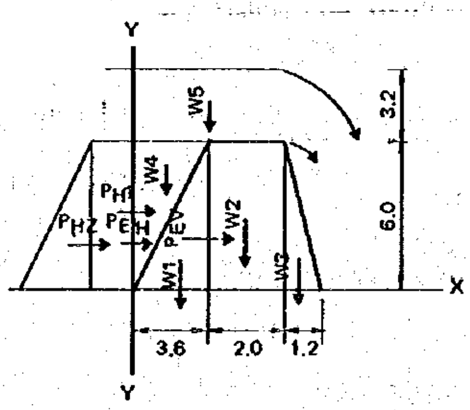
n = 1.38

According to the above, safety is confirmed.

Determination of the sub-dam cross-section:

Design conditions

Dam height; 6.0 m Other conditions are as same as of main dam



Horizontal component force

		Force	Arm	Moment
P_{H1}	3.2x6.0x1.2	23.03	3.0	69.12
P_{H2}	6.0x6.0x1/2x1.2	21.60	2.0	43.20
P_{EW}		6.96	2.45	17.05
P_{EH}		3.82	3.70	14.13
	Total	55.42		143.50

≒ 2.58

Vertical component force

		Force	Arm (X)	Moment	Arm (Y)	Moment
W_1	3.6x6.0x1/2x2.2	23.76	2.4	57.02	2.0	47.52
W_2	2.0x6.0x2.2	26.40	4.6	121.44	3.0	79.20
W_3	1.2x6.0x1/2x2.2	7.92	6.0	47.52	2.0	15.84
	Total	58.08				142.56
		$y = 2.45$				
W_4	3.6x6.0x1/2x1.2	12.96	1.2	15.55		
W_5	3.2x5.6x1.2	21.50	2.8	60.20		
P_{EV}		2.29		5.08		
	Total	94.83		306.81		
		$x_1 = 3.23$				

Full dynamic water pressure due to seismic force

Pd = 2 cm/2. Wo. Kd. H^2 . Sec θ

where,

α = 1.45, cm = 0.54, Wo = 1.2

Kd = D12 H^2 ($92^2 - 3.2^2$), Sec θ = 1.166

Pd = 446

Horizontal component force of dynamic water pressure

4.46 x cos = 3.82

Vertical force of dynamic water pressure

4.46 x sin = .2.29

Acting point of dynamic water pressure

hd = β H

β = 0.403, H = 9.2, hd = 3.7

Acting point of vertical component force

3.7 x tanθ = 2.22

Acting point of resultant force

X_2 : 2.58 = 55.42 : 94.83

X_2 : 1.50

$X_1 + X_2 = 3.23 + 1.50 = 4.73$

Eccentric distance

$$e = \frac{B}{2} \sim 4.73 = 1.33$$

Compressive force at the down-stream end

$$P_1 = \frac{\Sigma V}{B} (1 + \frac{6.C}{B})$$

$$= 13.9 \times 2.2$$

$$= 29.1$$

Compressive force at the up-stream end

$$P_2 = 13.9 \times -0.1$$

$$= -1.3$$

While the down-stream end's compressive force of 29.1 t/m^3 and the upstream end's tensile force of 1.3 t/m^3 will act, assuming them safe, the assumed cross-section will do.

Examination on depth of the sub-dam foundation from the river-bed: When run-fff sediment from up-stream temporarily became 0 due to completion of the dam, the present river-bed materials are limited to rare boulders of about 20 cm in diameter and the rest consits of pebbles and sand, so that lowering of the river-bed downstream of the dam is anticipated.

Judging from the longitudinal section of the present riverbed and supposing that there is no change of the riverbed and the exposed rock portion of the fall 1 km downstream from the dam is fixed, and such a case is considered as the riverbed is lowered to the present riverbed gradient of 1/63 from the dam to the fall:

Distance between fall and dam; 987.0 m

Elevation of fall; 248.32 m

Elevation of 1/63 at the sub-dam

15.67 + 248.32 = 263.99 m

The sub-dam foundation; 260.0 m

Polymerization; 3.99 m

When it is calculated according to the riverbed gradient 1/75 of the Pasig River,

Polymerization; 1.48 m

Anticipating some danger in this case, 3 rows of riverbed protecting concrete block of 3.0 m x 2.0 m x 2.0 m are provided at the downstream of sub-dam to prevent scouring, and elevation of sub-dam foundation was set at EL.260.0 m.

Apron thickness

When the dam height is 15.0 m - 20.0 m, thickness of apron is set at 2.0 m experimentally.

Apron length

The experimental formula

$$L = (H + t) \quad (1.5 \sim 2.0)$$

where,

H = Dam height (effective height) 10.0 m

t = Overflow water depth 3.2 m

$$L = (10.0 + 3.2) \quad (1.5 \quad 2.0)$$

$$= 19.8 \sim 26.4$$

Then opron length set at L = 23.0 m

Crest height of the sub-dam

The experimental formula:

$$W = H\left(\frac{1}{3} \sim \frac{1}{4}\right)$$

where,

H = Dam height (excluding apron thickness) 13.0 m

$$W = 13\left(\frac{1}{3} \sim \frac{1}{4}\right)$$

$$= 4.3 \sim 3.25$$

Then crest height of the sub-dam was set at 3.0 m

Calculation of the sheet pile length: As the foundation ground of No.5 dam is sand and gravel deposit, decrease of foundation bearing power and increase of up-lift pressure due to seepage flow caused by difference of water level between the main dam and sub-dam are anticipated. Therefore the sheet piles are driven at along the up-stream toe portion of main dam to prevent these actions by longthenning seepage flow length.

HH = Water-level difference. Water-level difference between the main dam and sub-dam: 10.0 m.

L = Necessary seepage flow length

$$L = 5 \times 10 = 50$$

ℓ = Length of the sheet pile

$$50 = 23.0 + 12.5 \times 1.4 + 2.0 + 2\ell$$

$$\ell = 5.6$$

Although the effective length of sheet pile is enough with 5.6 m, sheet pile of 10 m is used including cut slope retaining purpose and an allowance.

Ground sill location: It is 500 m from where is a terrace zone consisting of pyroclastic rock deposits in both banks.

Purpose of ground sill: The same as No. 1-A, B.

Structure of ground sill: The same as No. 1-A, B. The same condition is applied to the overflow section.

2.4.3 (2) Ground sill work

Outline of catchment: The catchment area 22.0 km^2; the present riverbed gradient 1/75.

Grand sill location: It is located at the sub-control point, and is 28.0 km from the Guagua River confluence.

Purpose and structure condition of ground sill are the same as other ground sills.

2.4.3 (3) Groyne work

Groyne works are located in the Pasig-potrero river and Papatac river between No. 1-A ground sill and No. 2-A Sabo dam to stabilize and adjust the river course. As the height of the groyne, 2.15 m in height, which derived from water depth of 1.65 m at design flood discharge of 600 m^3/s and an allowance of 0.5 m, is enough, but actually 2.40 m in height of the groyne which made up of four layers of 0.6 m thick gabion mat is applied. A berm of 0.5 m and 1.5 m is provided at the upstream slope and downstream slope respectively, and also width of the berms in the water are 2.0 m and 3.0 m at the upstream and downstream to protect the top of groyne from scouring due to river flow.

2.4.4 Afforestation Plan

The following are the types of vegetations suitable for planting.

(1) Kamachile (Camachile)

This is of the bear family and is similar to acacia (mimosa).

According to the book "Tropical Plants and their cultivation" by L. Bonggeamann, the description of the plant is as follows:

'Pithecellobium dulce (Roxb.) Benth (Leguminosae). Tree 15-40 m high, native of Central America with, rath pendant branches. It is sometimes used for hedges. Leaves compound. Flower small, white, united into small heads on terminal paniceles. Pods long and bent, up to 4 inches long, sinuated between the seeds. Seeds few, black, surrounded by a white edible coat. Propagated by seed. Should be grown below 2,500 ft. Often referred to as the "Monkey's eat. Not suitable for greenhouse cultivation.'

The excretion of the back is used for tanning leather and the meat coating the seed is edible.

(2) Kakawati Kakauti

Madre-cacao Gliricidia sepium (Jacq.) Stend (Leg.) This is a bush like tree that was migrated from South America and grows in the jungle.

It is an important fuel wood.

(3) Ipil-Ipil

Leucaena leucacephala (Lam) deWit (Leg)

This is also a migrated plant from South America and grows will in secondary forest. It is usually grown to deter the presence of Alan-alan.

(4) Alibangbang

Pikostigma malabaricum (Rexb.) Benth var. acidum (Korth) de Wit (Leg.)

This is a small tree commonly found in the forest and the name is derived from the fact that the leaves bear resemblance to butterflies.

(5) Pine tree

A tree that propagete naturally.

(6) Grama grass

This is growing very rapidly on the embankment.

(7) Cogon grass

A grass that propagates profusely on the river bed or on the embankment, and resembles "kaya" or pampas grass in Japan.

2.5 Construction Plan

2.5.1 General

It is desirable to bring the balance of design sediment discharge close to design exceed sediment discharge as scheduled after control and arresting by the Sabo dams, and is recommended to carry out the Sabo works taking into consideration the river improvement plan and progress under construction.

2.5.2 Implementation Plan

Regarding the construction of the Sabo dams, it is desirable to implement under following order, namely No.5 dam in the Timbu river at first and No. 4-A dam in the Bucbuc river next where have most abundant sediment production, and No.3, No. 2-B and No. 2-A in the Papatac river and No. 4-B, C, D, E, F successively. As for the ground sill works, it is also desirable to implement under the order of No. 1-D, C, B and A from the next year of completion of the Sabo dam No. 4-A in parallel with construction of the Sabo dam.

Construction period was estimated at 15 years for completion of the whole Sabo facilities with the considerations that daily concrete placing volume is 55 m^3 in average and possible concrete placing volume in one dry season is 4,000 m3 in the mountaineous site and 7,000 m3 in the plane site respectively. Though the excavation work of dam foundation and the concrete work can be executed in dry season only, the preparatory works such as construction of access road and construction facilities shall be carried out even in wet season. The implementation schedule of the Sabo works is as shown on FIGURE II-9.

For construction of the Sabo facilities, in order to expedite the works during limitted dry season, the excavation work, concrete batching, mixing, transportation and placing works will be executed by mechanical power. The main required construction equipment is listed in TABLE II-1.

2.6 Construction Cost and Budgetary Schedule

2.6.1 Economic Cost and Financial Cost

Financial cost or project cost is estimated at P137.8 million. By deducting taxes and duties on the imported materials for the construction, economic cost is estimated at P127.6 million. Details of the cost estimates are presented in TABLE II-2 and TABLE II-3.

2.6.2 Managing and Maintenance Cost

Managing and maintenance cost of the Sabo dam are mainly for maintenance and repairing of wear down and break off at the overflow crest, wings and apron, and maintenance and restoration of the scoured site at the downstream riverbed of dam. Annual managing and maintenance cost for the facilities after completion of all Sabo works is estimated at 420,000 peso.

2.6.3 Yearly Budget Disbursement Schedule

Yearly budget disbursement schedule the project cost and the economic cost are as shown on TABLE II-4 and TABLE II-5.

TABLE II-1 MAIN CONSTRUCTION EQUIPMENT

Name	Capacity
Concrete batching and mixing plant	2t
Air compressor mobile	0.6 m^3
Water pump	1,000 ℓ/min, Head 15 m
Mobile crane	2t
Bulldozer	5 ton class
Drag shovel	0.6 m^3
Dump truck	5t - 6t

TABLE II-2 FINANCIAL COST OF EACH SABO FACILITY

Item \ Facility		No.1-A	No.1-B	No.1-C	No.1-D	No.2-A	No.2-B	No.3	No.4-A	No.4-B	No.4-C	No.4-D	No.4-E	No.4-F	No.5	TOTAL
Earth Work	F	221	194	183	232	114	112	65	60	58	50	61	56	50	74	1,530
	L	883	778	733	928	456	447	259	238	230	200	242	223	202	296	6,115
	T	1,104	972	916	1,160	570	559	324	298	288	250	303	279	252	370	7,645
Structure Work	F	2,316	1,887	1,714	3,148	1,552	1,496	969	939	982	791	1,141	961	783	861	19,540
	L	7,753	6,316	5,738	10,540	5,199	5,009	3,244	3,144	3,288	2,648	3,822	3,218	2,620	2,895	65,434
	I	10,069	8,203	7,452	13,688	6,751	6,505	4,213	4,083	4,270	3,439	4,963	4,179	3,403	3,756	84,974
Pre-paratory Work	F	45	37	34	62	30	29	19	18	19	16	22	19	15	15	380
	L	861	701	637	1,170	578	556	360	349	365	294	425	357	2291	348	7,292
	T	906	738	671	1,232	608	585	379	367	384	310	447	376	306	363	7,672
Admini-stration cost	F															
	L	1,000	800	700	1,300	700	600	400	400	400	300	500	400	300	400	8,200
	T	1,000	800	700	1,300	700	600	400	400	400	300	500	400	300	400	8,200
Con-tingency	F	385	313	284	522	259	247	161	156	162	130	190	159	129	153	3,250
	L	1,540	1,253	1,134	2,086	1,037	990	642	623	650	522	759	637	515	632	13,020
	T	1,925	1,566	1,418	2,608	1,296	1,237	803	779	812	652	949	796	644	785	16,270
Engineer-ing Cost	F	407	407	407	407	407	407	407	407	407	407	407	407	407	409	5,700
	L	523	523	523	523	523	523	523	523	523	523	523	523	523	521	7,320
	T	930	930	930	930	930	930	930	930	930	930	930	930	930	930	13,020
Total	F	3,374	2,838	2,622	4,371	2,362	2,291	1,621	1,580	1,628	1,394	1,821	1,602	1,384	1,512	30,400
	L	12,560	10,371	9,465	16,547	8,493	8,125	5,428	5,277	5,456	4,487	6,271	5,358	4,451	5,092	107,381
	T	15,934	13,209	12,087	20,918	10,855	10,416	7,049	6,857	7,084	5,881	8,092	6,960	5,835	6,604	137,781

F: Foreign Currency. L: Local Currency. T: Total Amount.

TABLE II-3 ECONOMIC COST OF EACH SABO FACILITY

(Without Tax)

Item \ Facility		No.1-A	No.1-B	No.1-C	No.1-D	No.2-A	No.2-B	No.3	No.4-A	No.4-B	No.4-C	No.4-D	No.4-E	No.4-F	No.5	Total
Earth Work	F	131	115	109	139	69	68	40	37	35	31	37	34	31	44	920
	L	873	768	723	923	457	450	265	243	232	205	245	226	203	302	6,115
	T	1,004	883	832	1,062	526	518	305	280	267	236	282	260	234	346	7,035
Structure work	F	1,354	1,102	1,001	1,846	912	879	570	553	578	466	672	566	460	511	11,470
	L	7,724	6,285	5,708	10,533	5,202	5,012	3,252	3,152	3,297	2,657	3,836	3,228	2,626	2,922	65,434
	T	9,078	7,387	6,709	12,379	6,114	5,891	3,822	3,705	3,875	3,123	4,508	3,794	3,086	3,433	76,904
Pre-paratory Work	F	24	20	19	31	14	14	9	9	9	7	10	9	7	8	190
	L	928	777	716	1,192	542	522	338	329	344	278	400	337	274	315	7,292
	T	952	797	735	1,223	552	536	347	338	353	285	410	346	281	323	7,482
Admini-stration cost	F															
	L	1,000	800	700	1,300	700	600	400	400	400	300	500	400	300	400	8,200
	T	1,000	800	700	1,300	700	600	400	400	400	300	500	400	300	400	8,200
Con-tingency	F	229	186	168	310	155	158	96	93	97	78	114	95	77	94	1,950
	L	1,529	1,242	1,125	2,071	1,033	1,052	641	624	647	520	759	637	514	626	13,020
	T	1,758	1,428	1,293	2,381	1,188	1,210	737	717	744	598	873	732	591	720	14,970
Engineer-ing Cost	F	407	407	407	407	407	407	407	407	407	407	407	407	407	409	5,700
	L	523	523	523	323	523	523	523	523	523	523	523	523	523	521	7,320
	T	930	930	930	930	930	930	930	930	930	930	930	930	930	930	13,020
Total	F	2,145	1,830	1,704	2,733	1,557	1,526	1,122	1,099	1,126	989	1,240	1,111	982	1,066	20,230
	L	12,577	10,395	9,495	16,542	8,457	8,159	5,419	5,271	5,443	4,483	6,263	5,351	4,440	5,086	107,381
	T	14,722	12,225	11,199	19,275	10,014	9,685	6,541	6,370	6,569	5,472	7,503	6,462	5,422	6,152	127,611

F: Foreign Currency. L: Local Currency. T: Total Amount

TABLE II-4 FINANCIAL COST

(10^3 peso)

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Total
Earth Work	F	40	84	18	162	255	263	239	121	59	40	57	61	59	55	17	1,530
	L	162	335	75	646	1024	1054	954	487	232	162	228	239	234	219	64	6,115
	T	202	419	93	808	1279	1317	1193	608	291	202	285	300	293	274	81	7,645
Structural Work	F	252	803	718	1430	2608	3210	2705	2074	624	949	881	966	1051	874	395	19,540
	L	843	2688	2407	4790	8736	10750	9060	6944	2087	3177	2946	3243	3516	2928	1319	65,434
	T	1095	4586	3125	6220	11344	13960	11765	9018	2711	4126	3827	4209	4567	3802	1714	84,974
Preparatory Work	F	11	16	0	66	73	62	66	14	6	14	10	19	14	9	0	380
	L	202	320	0	1255	1392	1173	1262	276	118	272	190	370	261	201	0	7,292
	T	213	336	0	1321	1465	1235	1328	290	124	286	200	389	273	210	0	7,672
Administration Cost	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	L	120	320	359	587	1070	1321	1087	956	216	482	339	401	452	345	145	8,200
	T	120	320	359	587	1070	1321	1087	956	216	482	339	401	452	345	145	8,200
Contingency	F	0	0	290	0	149	749	293	586	0	267	173	147	202	173	221	3,250
	L	0	0	1156	0	598	3001	1176	2343	0	1072	692	592	808	696	886	13,020
	T	0	0	1446	0	747	3750	1469	2929	0	1339	865	739	1010	869	1107	16,270
Engineering Cost	F	380	380	380	380	380	380	380	380	380	380	380	380	380	380	380	5,700
	L	489	489	489	489	489	489	489	489	489	489	489	489	489	489	474	7,320
	T	869	869	869	869	869	869	869	869	869	869	869	869	869	869	854	13,020
Total	F	683	1283	1406	2038	3465	4664	3683	3175	1069	1650	1501	1573	1706	1491	1013	30,400
	L	1816	4152	4486	7767	13309	17788	14028	11495	3142	5654	4884	5334	5760	4878	2888	107,381
	T	2499	5435	5892	9805	16774	22452	17711	14670	4211	7304	6385	6907	7466	6369	3901	137,781

F: Foreign Currency

L: Local Currency

T: Total Amount

TABLE II-5 ECONOMIC COST

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Total
Earth Work	F	24	51	11	98	153	157	144	74	35	24	35	37	35	33	9	920
	L	162	335	75	646	1,024	1,054	954	487	232	162	228	239	234	219	64	6,115
	T	186	386	86	744	1,177	1,211	1,098	561	267	186	263	276	269	252	73	7,035
Structural Work	F	147	471	422	840	1,532	1,884	1,588	1,218	366	557	517	568	616	513	231	11,470
	L	844	2,689	2,407	4,790	8,736	10,749	9,060	6,944	2,087	3,177	2,946	3,243	3,516	2,928	1,318	65,434
	T	991	3,160	2,829	5,630	10,268	12,633	10,648	8,162	2,453	3,734	3,463	3,811	4,132	3,441	1,549	76,904
Preparatory Work	F	5	8	0	33	36	31	33	7	3	7	5	10	7	5	0	190
	L	202	320	0	1,255	1,393	1,173	1,262	276	118	272	190	370	261	200	0	7,292
	T	207	328	0	1,288	1,429	1,204	1,295	283	121	279	195	380	268	205	0	7,482
Administration Cost	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	L	120	320	359	587	1,070	1,320	1,086	956	216	482	339	401	452	345	147	8,200
	T	120	320	359	587	1,070	1,320	1,086	956	216	482	339	401	452	345	147	8,200
Contingency	F	0	0	174	0	89	449	176	351	0	161	104	89	121	104	132	1,950
	L	0	0	1,156	0	598	3,001	1,176	2,343	0	1,072	692	592	809	697	884	13,020
	T	0	0	1,330	0	687	3,450	1,352	2,694	0	1,233	796	681	930	801	1,016	14,970
Engineering Cost	F	380	380	380	380	380	380	380	380	380	380	380	380	380	380	380	5,700
	L	489	489	489	489	489	489	489	489	489	489	489	489	489	489	474	7,320
	T	869	869	869	869	869	869	869	869	869	869	869	869	869	869	854	13,020
Total	F	556	910	987	1,351	2,190	2,901	2,321	2,030	784	1,129	1,041	1,084	1,159	1,035	752	20,230
	L	1,817	4,153	4,486	7,767	13,310	17,786	14,027	11,495	3,142	5,654	4,884	5,334	5,761	4,878	2,887	107,381
	T	2,373	5,063	5,473	9,118	15,500	20,687	16,348	13,525	3,926	6,783	5,925	6,418	6,920	5,913	3,639	127,611

F: Foreign Currency

L: Local Currency

T: Total Amount

FIGURE II-1 UNSTABLE SEDIMENT ON THE CROSS-SECTION

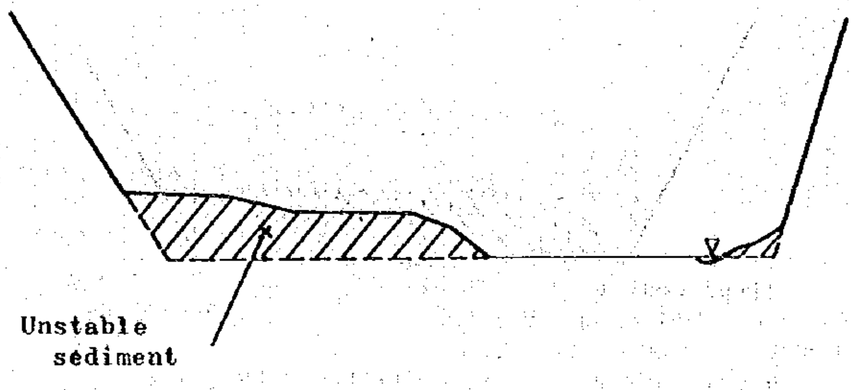


FIGURE II-2 UNSTABLE SEDIMENT ON THE LOGITUDINAL SECTION

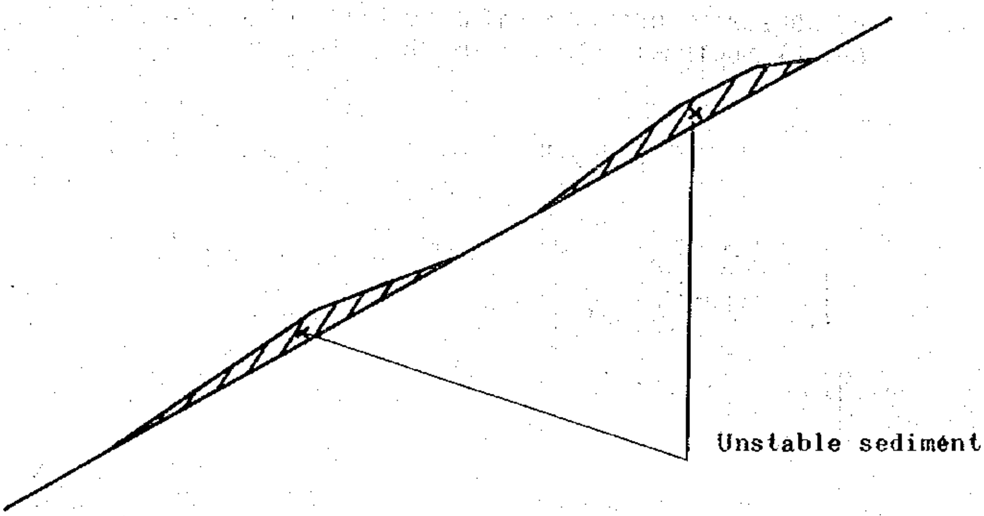


FIGURE II-3 UNSTABLE SEDIMENT ON THE RIVER-BED CROSS-SECTION OF THE PASIG RIVER

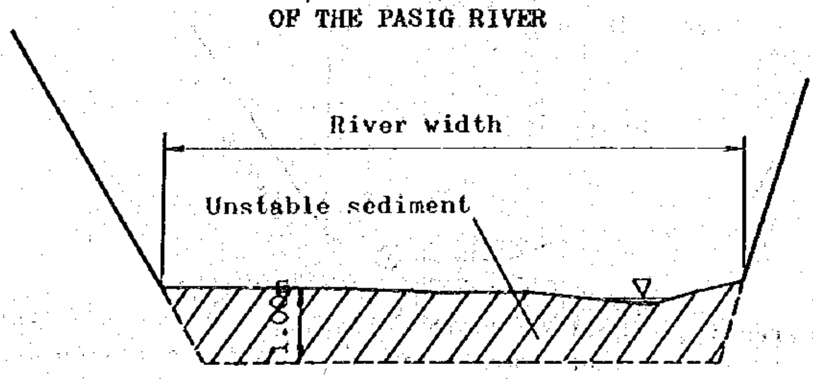
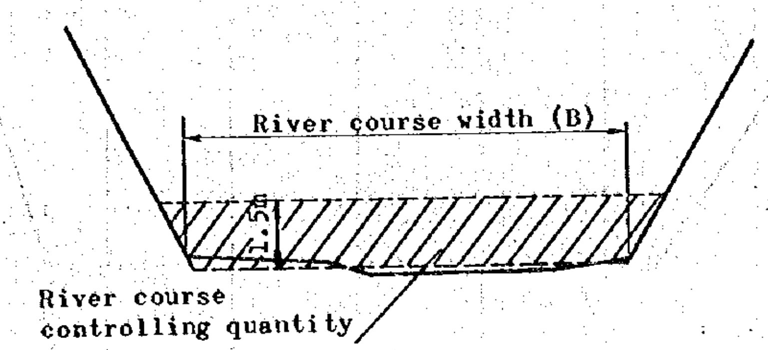
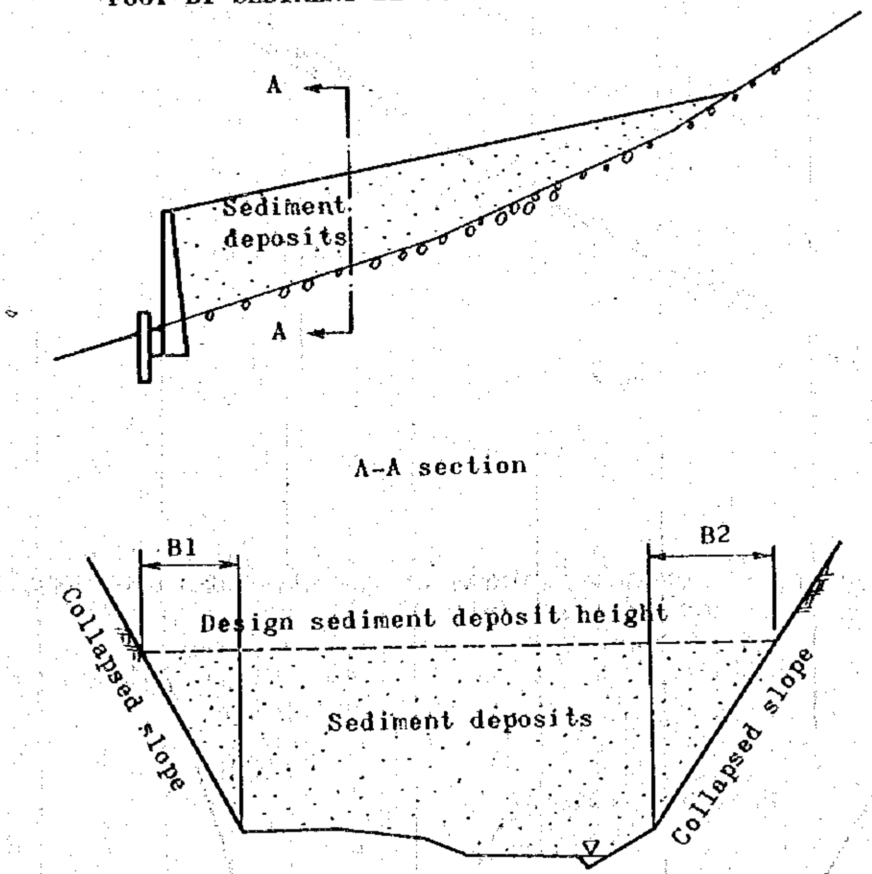


FIGURE II-4 CALCULATION OF THE RIVER COURSE CONTROLLING QUANTITY ON THE RIVER-BED CROSS-SECTION



River course controlling quantity = River course width (B) x 1.5

FIGURE II-5 THE ARRESTING QUANTITY OWING TO FIXATION OF MOUNTAIN FOOT BY SEDIMENT DEPOSITS OF THE SABO DAM



Production arresting quantity = Section where collapsed slope was buried (B_1 + B_2) x Maximum flood time errosion depth (0.2 x 8)

FIGURE II-6 CONTROL QUANTITY BY THE SABO DAM

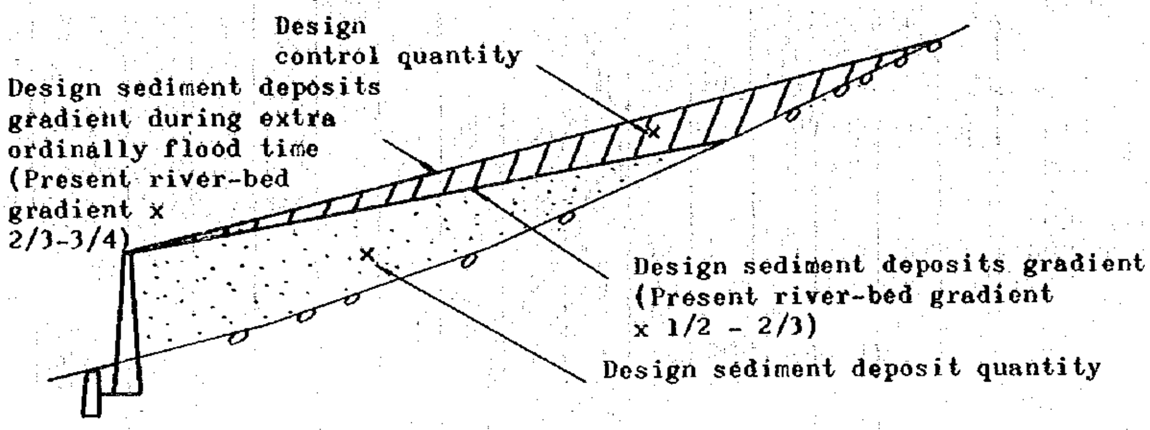
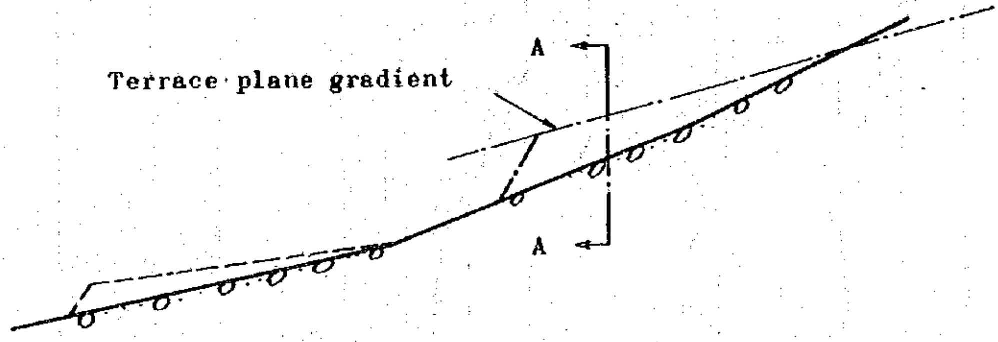


FIGURE II-7 LONGITUDINAL GRADIENT OF TERRACE PLANE



A-A section

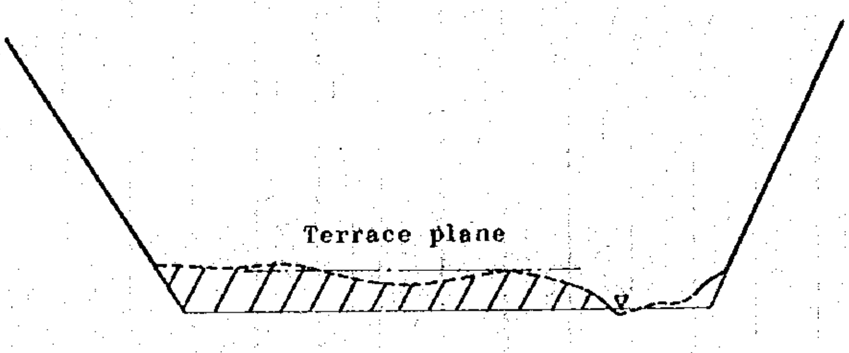


FIGURE II-8 LOCATION OF SABO FACILITIES

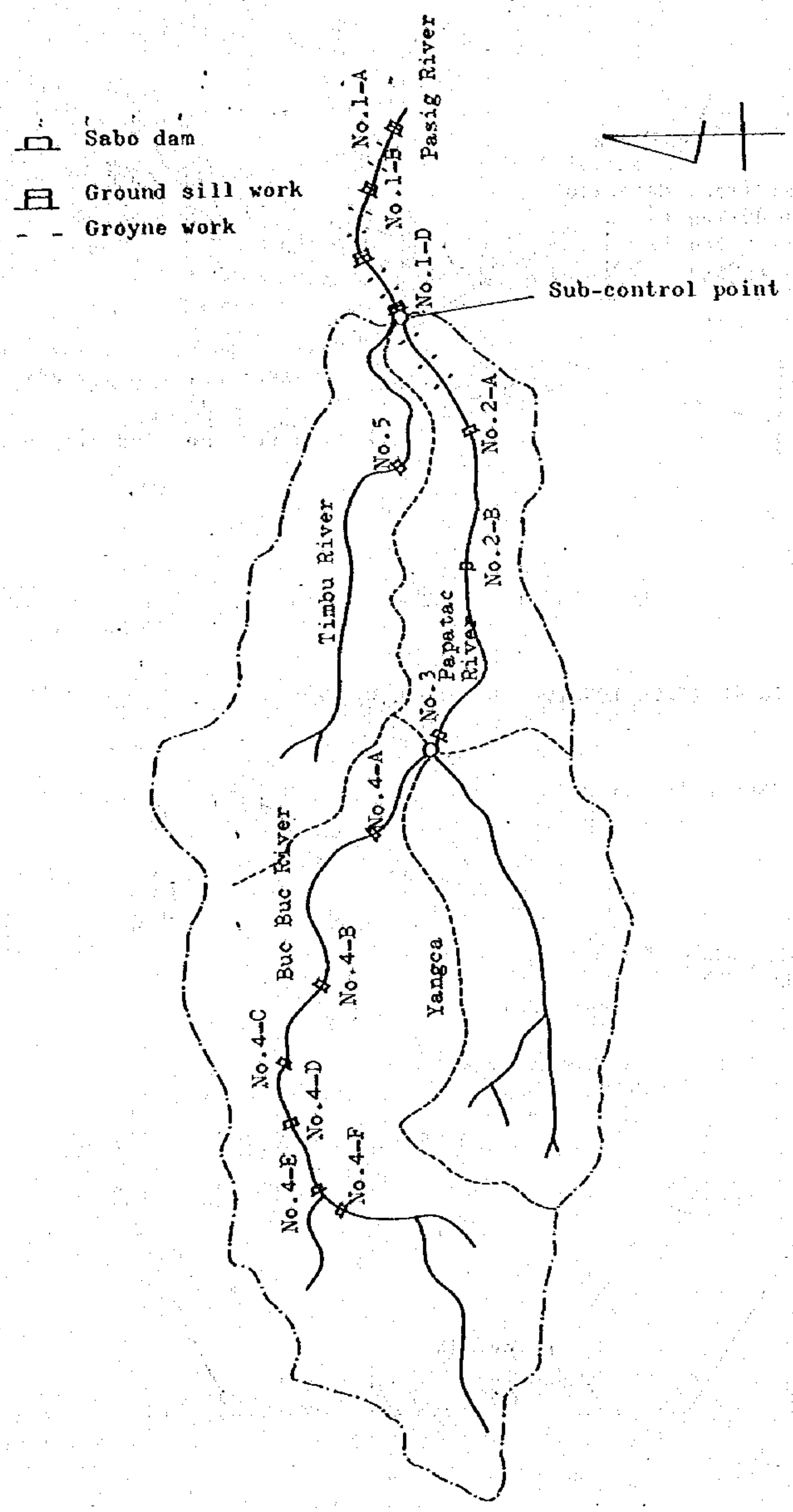


FIGURE II-9 IMPLEMENTATION SCHEDULE

Work	Q'ty	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	9th year	10th year	11th year	12th year	13th year	14th year	15th year
No.5	6,870		P.W	E&C.W												
No.4-A Dam	6,920		P.W	E&C.W												
No.3 Dam	7,110			P.W	E&C.W											
No.1-D Con.W	22,890			P.W	E&C.W	E&C.W										
No.1-C Con. W	11,950					P.W	E&C.W									
No.1-B Con. W	13,220						P.W	E&C.W								
No.1-A Con. W	16,390							P.W	E&C.W							
No.2-B Dam	10,870						P.W	E&C.W	E&C.W							
No.2-A Dam	11,300								P.W	E&C.W	E&C.W					
No.4-B Dam	7,280										P.W	E&C.W				
No.4-C Dam	5,830											P.W	E&C.W			
No.4-D Dam	8,520												P.W	E&C.W		
No.4-E Dam	7,130													P.W	E&C.W	
No.4-F Dam	5,760														P.W	E&C.W

P.W: Preparatory Work. E&C.W: Earth and Concrete Work Con.W.: River Bed Consolidation Work.