CHAPTER 9

LAUNDER AND PIPELINE CONSTRUCTION PLAN

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9.1 LAUNDER LINE CONSTRUCTION PLAN (See Figs. 1 and 2)

9.1.1 Working Sections and Extensions

The launder line will be laid down over a length of 19.7 km, which accounts for about 76% of the total length of the common line. The part of the lauder to be laid down inside the tunnel will be 15 km, and the part extending out of the tunnel will be 4.7 km or about 76% and 24% of the total launder line length respectively.

The launder extensions and sections are shown in Table 9-1.

Table 9-1 Launder Extensions and Sections

Division	Total extension	Section	Extension	Remarks
Inside the tunnel	(m) 15,000	A - B	2,400 (m)	
		B - C	1,700	
		C - E	1,900	
		F - G	2,500	
		G-(H)-I	2,000	G-H... 60 m including bridge
		I - J	2,500	
		J-(K)-L	2,000	J-K... 350 m, including bridge and supports
Outside the tunnel	4,700	M - N	4,700	
Total	19,700			

9.1.2 Manufacture of Launder

(1) Prefabrication

There are other problems on the construction of the launder line aside from the fact that it has a total distance of 19.7 km, the working space is very limited in the tunnel and the launder line outside the tunnel is mostly laid on the supports several meters high so that the launder has to be prefabricated in a factory in consideration to the following advantages.

. Advantages

a. The factory prefabrication ensures a more rigid quality control than the concreting in site.

b. The factory prefabrication is better than the concrete in site considering the accuracy of the launder size and its installation gradient.

c. The prefabrication can be carried out simultaneously with the tunnel excavation work and erection of launder supports, thereby reducing the time required in laying the launders, particularly in the tunnel.

d. It is possible to obtain the required concrete strength by taking an adequate amount of time from the start of the launder fabrication to the comencement of flowing the tailings slurry.

e. The concrete surface will be smoothly flat and better suited for a launder than the in-site concreting.

. Disadvantages

a. Reinforced concrete is heavy that it requires bigger equipment.

b. Greater care is needed in handling so as not to damage the prefabricated launder which has to be transported to the site from the factory unlike in the in-site concreting, the raw materials has to be hauled to the site.

(2) Launder Prefabrication Plan

The plant where the launder is to be prefabricated has to be located along the national road, about 1.5 km west of Rosario. This is the most convenient site for the plant considering its proximity to the Bued River which is the source of the concrete aggregates. Furthermore, the prefabricated launder blocks has to be laid over a long distance and also for the convenience of the workers who has to commute to the plant.

The plant scale will be as follows:

a. Plant site area: 20,000 m^2

This will include the space for stockyard of launder blocks, aggregates storage, administrative office, laboratory, passageways, etc. Since the launder line is to be laid almost at the same time inside the tunnel, it is necessary to provide a stockyard (14,000 m^2) for storing about 3,700-launder blocks required to build about 14 km of launder line.

b. Number of launder blocks to be made: 5,250

The above figure is for a launder line 19,700 m long plus 6% allowance for loses due to damage in handling. A prefabricated launder should be 4 m in length, 5.2 tons in weight.

c. Concrete mixer capacity: 0.75 m^3 (min. 24 m^3/day)

d. Facilities incident to concrete mixer

a) Cement silo: 630 tons in capacity (for 10 days)
b) Water supply facilites
c) Aggregate supply facilities

e. Crane

The crane is to be used to strip the forms and to haul the launder blocks to the reverser and also to do other jobs.

travelling crane girder 5 m height x 80 m length x 2 row
Hoisting load 6 t, crane span 20 m, lift 5 m

f. Launder reverser: 1 unit

When stripped of the form, the launder block is left upside down and it is turned up by the use of the reverser.

g. Steel form 100 sets

In order to ensure a rigid quality control, it is necessary to set up a laboratory where the concrete strength test will be conducted by a technician employed on a fulltime basis for this job. Eleven launder blocks will be made per day on the average in the factory, and nineteen months are required to make 5,250 launder blocks. After being cured and separated from the steel forms at the yard, the launder should be hauled by forklifts 7 to 10 tons in capacity to the stockyard where they should be further cured until the required strength and thereafter will be delivered to the place where required. They will loaded onto the trucks by the forklifts.

The sequence of launder manufacturing processes is briefly described below.

→ Surface treatment of forms (steel) → Assembling of forms → Insertion of reinforcement → Placing of concrete → Curing → Disassembling of forms → Reversing of launder block → Hauling to the stockyard

As mentioned above, the launder block is so heavy that four pieces of small-bore steel pipes are embedded in it so that it can be hoisted with the tips of the hangers fitted into the embedded pipes.

Fig. 9-1 shows the details of the hanging hole and the hanger.

9.1.3 Launder Installation Work

(1) Preparatory work

a, Access roads (See Fig. 9-2)

The launder line is laid almost parallel to the national highway leading from Rosario toward the Lingayen Gulf. As for the access roads, the existing roads has to be widened specially on the approaches to the launder line. A new road has to be constructed alongside the launder line for erecting the launder supports and in laying the launder line.

As for the approach from the national highway, there are three conceivable routes. These roads are all about 3 m wide, just enough to allow the passage of a jeep, at the present time and eventually be widened to 5 m to accommodate trucks loaded with construction materials. The first route is leading southward from Rosario, which is about 600 m long, flanked by rice paddies on both sides dotted with farm houses. The second route is about 850 m long, which is leading southward from a point about 2.5 km west of Rosario, passing through dry fields. There are farm houses on both sides of this road within about 300 m from the point where it branches from the national highway but thereafter there are few houses in its vicinity. The third route begins southward at a point about 300 m from the national highway bridge over the Apangat River with a length of about 1,100 m. These roads should be widened as stated above, graded and then covered with mixture of gravel and sand taken from the dry bed of the Apangat River so that they will be able to allow the passage of the trucks loaded with equipment and materials.

The new road will be built alongside the pipeline and launder line, turning westward from where it crosses the national highway to reach the eastern side of the Apangat River. It will have a total length of about 4,800 m and will cross two of the above mentioned three approaches. Of the total length of the new road, about 2,000 m stretch from Udeo will pass through rice paddies and the rest about 2,800 m will run through dry fields. It will be built as wide as 5 m to allow passage of trucks carrying equipment and materials. It will be necessary to make proper repairs of the road base if damaged after a rainy season. After completion of the common line construction work, this road can be used for patrolling.

b. Erection of launder supports

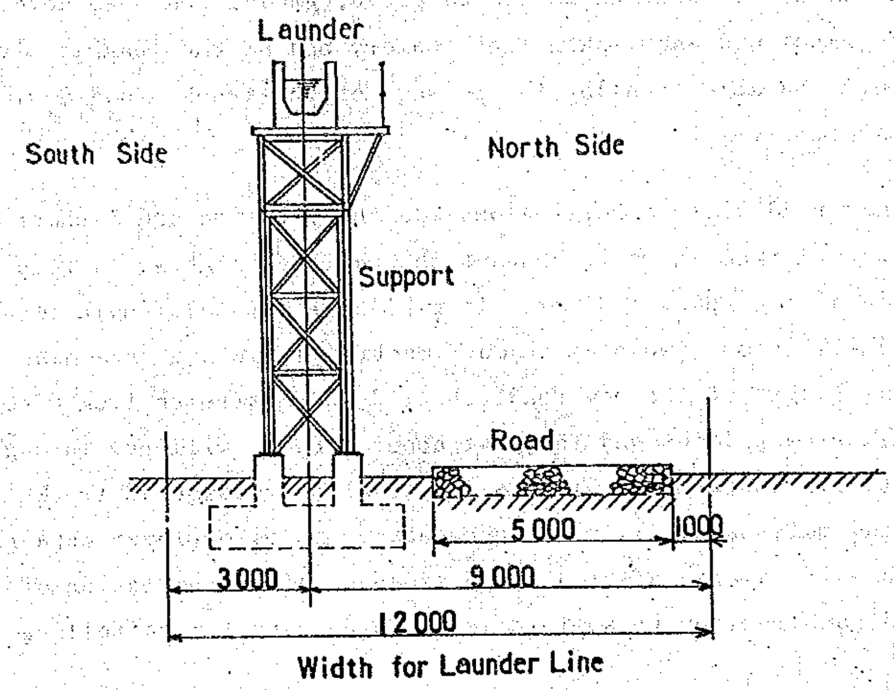
The launder will be laid from the point M to N after passing the Bued River. It is necessary for the launder line to be laid for the most part on the supports in this area which consists of rice paddies and dry fields, since the topography and the gradient of the launder line require the use of the supports.

The launder support is illustrated in Fig. 7-5 in Chapter 7. The launder supports should be erected on the south side of the new access road, so that the approach branching from the national highway will not intersect the launder line.

This arrangement also has the advantage that the shadows of the launder line and supports will fall only on the new access road, not shading the sunlight for the farmland on the north side of the launder line.

The relationship between the launder supports and the access road is shown Fig. 9-3.

Fig. 9-3 Relation Between Launder Support and Access Road



There will be provided 1,000 m^2 vacant lots, 20 m x 50 m, at intervals of 1 km alongside the new access road, so that they can be used as the stock yards for the launder support and other construction materials, thereby to facilitage the launder supports erection work. The pier and 10 m long supurstructure will be fabricated in a factory, and two superstructures will be conbined each other at the site. The combined 20 m length superstructure and the pier will be installed by means of truck crane.

One end of the combined structure will be rigidly fixed on the pier, but another end will be loosely fixed on the next pier by means of bolts through the loose holes drilled in the base plate on the pier so that the superstructure will be free from thermal expansion.

(2) Launder line construction work

a. Laying of launder line inside the tunnel

The part of the launder line to be constructed inside the tunnel is 15,000 m long. After completion of tunnel driving, at each working section, the launder will be carried into the tunnel, using trucks pulled by the 4-ton battery-driven locomotive employed in mucking. Inside the tunnel, the launder blocks will be unloaded by means of a simple portable crane, which can be assembled and disassembled in the tunnel. This crane has two chain blocks and the launder block is lifted at four points when unloading. Three launder blocks can be carried into the tunnel at one time. In order to eliminate the loss of time, it is necessary to have another trucks loaded with launder blocks at the portal so that the battery locomotive will not be kept waiting, for it is necessary to increase the efficiency of battery locomotive operation since the topography does not permit a sufficiently large space for stockpiling the launder blocks near the portal and the maximum distance of hauling the launder blocks through the tunnel is about 2.5 km long.

Prior to the launder block construction, there is the necessity for placing the launder base concrete. This base concrete should be placed at an average thickness of 10 cm. This thickness of the base concrete is essential to make proper adjustment to ensure that the launder line is laid to have a constant gradient of 1.25%. About 11 m^3 of concrete will be required per 100 m of launder line. The concrete mix also will be hauled to the battery-driven locomotive to the place where it is to be placed inside the tunnel.

The launder blocks will be tentatively set in place on the concrete base and permanently laid after having made certain by making a survey that it has a correct gradient. This requires the launder layers and surveyers to work in a team. The joints of the laid launder blocks shall be filled with mortar. In order to obtain a correct gradient of the launder line, liner will be used and any gap between the bottom of the launder blocks and the top surface of the base should be grouted with mortar.

b, Laying of launder line outside the tunnel

Outside the tunnel, a truck crane is used to lay down the launder blocks in place on the supports. Since the supports are made of steel, they expand when exposed to the solar radiation, and therefore the joints between launders may be affected to develop gaps to allow a leaking of tailings slurry.

In order to prevent the occurrence of such accident, the adjacent launder blocks should be tightly fastened together by means of tie-bars through gib-headed plugs which have been fitted and welded in the hanging steel pipes embedded beforehand in the launder blocks as seen from Fig. 9-1.

The same method should be used to bind the launder blocks together for the launder line to be laid on the bridges between the points (G - H) and (J - K).

9.2 PIPELINE CONSTRUCTION PLAN (See Figs. 1 and 2)

9.2.1 Work Sections and Extensions of Pipeline

Two pipelines will be installed, and the pipelines installation work will be broadly divided into the following three sections as shown Table 9-2.

Table 9-2 Pipeline work Sections and Extensions

Construction section	Work section	Pipeline section	Extension	Remarks
Installation on the bridge	9	point point L - M	600 M	Bridge on Bued River See Fig. 7-8
Installation on the open ground	9	L - M	100 M	A section of pipelines with drop tanks
		L - M	300 M	A section before and after the Udeo national highway
	12	P - Q	4,200 M	Passes along a small river across the hill. 1,400 m of the line is laid on the supporting frames.
	8	J - K	(50M)	Connection pipes of 5-drop boxes
Installation in the tunnel	11	O - P	1,100 M	A section in the tunnel
Total			6,300 M	

9.2.2 Pipeline Construction Work Schedule

(1) Preparatory work

a. Access roads (See Fig. 9-2)

(a) Acess road to the point L

Since the road near Camp 1 on the east ban of the Bued River has been washed away by a flood, the access road to the point L, has to be started near Dongon, that is, a point about 1,100 m southward toward the old road from the national highway bridge spanning the Bued River. The access road will have a length of about 800 m. Since this neighborhood is thickly wooded, it is necessary to fell the trees and it is only scarcely dotted with houses and there will be little trouble to the construction of a new road in this area. The construction of this road is necessary as a preparatory work for the tunnel excavation in Section 8.

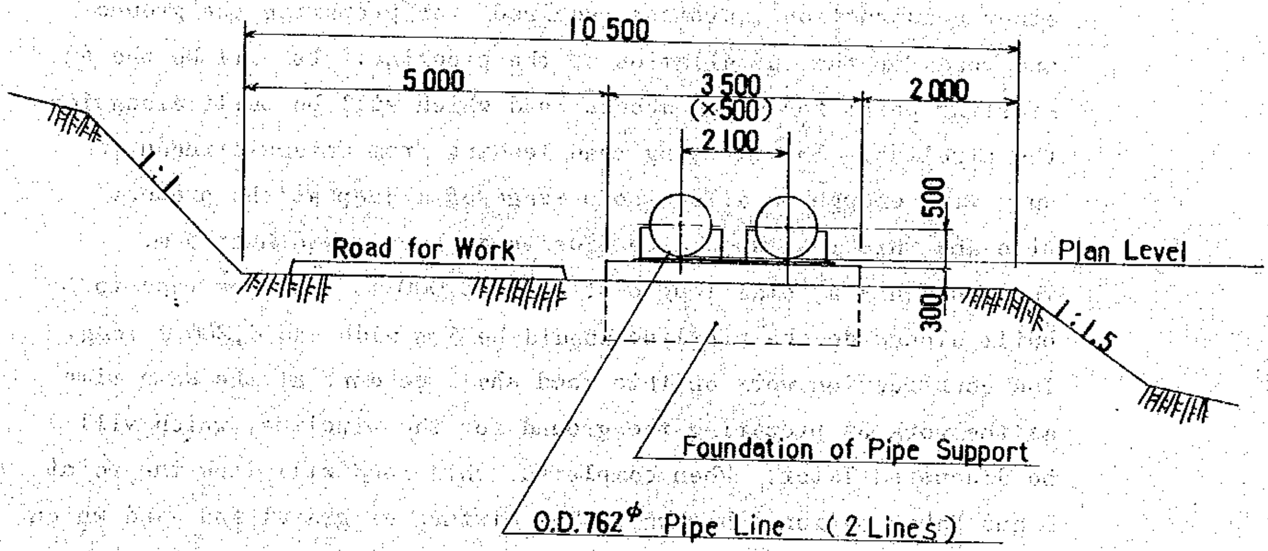
(b) Access road for Sections 11 and 12

It is necessary to widen the existing road running southward from Cataguintingan situated halfway between Rosario and Damortis. This road will make it possible to transport the bulldozers and other construction equipment required for preparing the ground and road for the installation of the pipeline. It will be the st starting point for a new access road which will be built alongside the pipeline. The existing road leading from Cataguintingan is only wide enough to allow the passage of a jeep at the present time and this road should be widened to have a width of 5 m. This road has a total length of about 2,000 m. The new road to be built alongside the pipeline should be 5 m wide ana 4,200 m long. The construction work on this road shall be done at the same time as the work of preparing the ground for the pipeline, which will be discussed later. When completed, this road will link the point L and Rabon national highway. The mixture of gravel and sand which is taken from the dry bed of the Bued River will be used in building the road.

b. Construction of pipeline bed

The pipeline bed construction work should be done in advance of the installation of the pipeline. The pipeline bed 10.5 m wide should be built along the pipeline level, cutting through the hillside. This section has few big trees and only has dry cultivated fields and waste land and also some rice paddies near the terminal point Q. It is desirable to balance the cutting and filling in building the pipeline bed. However, in view of the heavy rainfall in this region, the F/S mission have selected a route which will use mainly the cutting, taking into consideration the effect on the pipeline of the possible scouring of the bed by a flood caused by a heavy rainfall. The amount of earthwork is estimated to be about 42,000 m^3 for cutting and about 4,600 m^3 for filling. At present, only a topographical map on a scale of 1 to 50,000 is available for this area. A more detailed topographical map is required to make accurate calculations for the amount of earthwork and the routing of the pipeline. The pipeline bed is to have a total length of about 4,200 m. The standard cross section of the pipeline bed is illustrated in Fig. 9-4.

Fig. 9-4 Standard Cross Section of Pipe Line Bed



c. Pipeline foundations

The pipeline foundatations are of two types, the foundation inside the tunnel in Section 11 and the foundation outside the tunnel in Section 12. These foundations are made of reinforced concrete and placed at intervals of 10 m. The crown of the foundation will be 35 cm higher than the ground irrespective of the presence of concrete lining. The foundation will be 1.0 m wide and 35 cm thick.

Outside the tunnel, the crown of foundation will be 30 cm above the ground and the foundation will be 3.5 m wide and 50 cm thick. Both foundations are to be elevated above the ground level in order to ensure a sufficient space required for the work of tightening the bolts and nuts of the flange when installing the pipelines.

d. Intersections of pipelines and national highways

The proposed pipelines will cross national highways at two places, that is, in the Udeo area and in the Rabon area on the Lingayen Gulf.

(a) Intersection in the Udeo area

This national highway is a main road leading to Baguio and carries a heavy traffic. When crossing the national highway, the pipeline will be laid on a level 1.5 m underneath the road surface for reasons of the level of the pipeline crossing the Bued River, the topographical features and the level of paved surface of the road. The reinforced concrete culvert structure will be used when crossing the national highway. In order to avoid shutting of the road traffic, this work should be done first with one of the two lanes left open and when the half of the culvert work is completed the other lane will be opened to carry out the remaining half. The top of the culvert should be repaved with asphalts. The floor in the culvert box will be paved with concrete to prevent water from accumulating, after that the pipe lines are to be laid on the supports provided in the culvert box. The structural dimensions are shown in Fig. 9-5.

(b) Intersection in the Rabon area

This national highway leading from Damortis to Mabilao does not have so heavy traffic as the one in the Udeo area.

Near its terminal point, the pipelines will run alongside the river which flows into the Lingayen Gulf near Rabon and they are to be laid underneath the bridge spanning the river. Pipeline bed alongside the river 3.5 m wide should be built using sheet pipes on the side facing the river.

Parallel to the national highway, a railway line is running about 50 m apart on the side of the sea. The pipeline should also cross the railway line in the same manner as the national highway.

The intersection is illustrated in Fig. 9-6.

(c) Bridge over the Bued River

The bridge to be built over the Bued River will have a total length of 600 m. Piers and abutments will be built at each span of 40 m. The superstructure will be trussed, on which two rows of pipeline are to be laid.

The bridge construction work should be done, avoiding the rainy season when the Bued River may be flooded. The span between the bridge piers is 40 m and it weights about 30 tons in terms of truss weight. The truss structural members will be prefabricated to 10 m long and hauled from Camp 1 to the site by way of the temporary access road built on the dry river bed. At the site, the 10 m long members will be assembled to a length 20 m and set upon the bridge piers so that both ends will protrude 10 m from the edges of the piers on either side. After completion of setting the trusses on two adjacent piers, the remaining 20 m gap between the piers will be filled by setting a truss to connect the two trusses previously set on the piers. This process will be repeated to build the bridge.

(2) Laying of Pipeline

The flange fitting and pipe welding works, which are to precede the laying of the pipeline will be concentrated at several places provided alongside the pipeline. Therefore, the pipes transported from Manila will be unloaded at the respective places according to the plan made up in advance. The concentrated work places will be as follows.

Section 9	1 place
Section 11	1 place near the portal of the tunnel
Section 12	3 places
Section 8	1 place

a. Laying the pipeline in the tunnel

Pipeline is to be laid over a 1,100 m horizontal stretch in Section. The pipeline gradient should be -0.5%, equal to that of the tunnel driving. Outside the tunnel, two pipes, each 6 m in length, should be welded together to have a length of 12 m and both ends will be fitted with flanges which should be equivalent to the JIS 20 kg/cm^2 flanges. The pipes of 12 m length are to be carried to the site in the tunnel, using a hand truck running on a monorail track, which will be built on the ceiling of the tunnel. The monorail track will be made of I-beams. Brought into the tunnel, the pipes will be placed on the supporting foundations and connected together by means of bolts and nuts at the flange. The transportation of pipes in the tunnel is illustrated in Fig. 9-7.

b. Laying the pipeline on the bridge

The pipeline laying work on the bridge over the Bued River is planned as described below.

It is necessary to prepare two kinds of pipes, that is, some of the 6 m pipes are to be welded together to have a length of 12 m and one end of which is fitted with flange and some of the 6 m pipes will remain unwelded and be flanged on one end. They are to be transported by truck to the bridge from the concentrated work place. On the bridge will be laid two raid tracks and also a traveling portal crane to haul the pipes. Using two chain blocks 2 tons in capacity, one 12 m pipe or two 6 m pipes will be carried at one time by a hand truck. On the truss bridge, the 6 m and 12 m pipes will be placed alternately so that the flange intervals will be 18 m. Adjacent no flanged pipe end will be welded on the site.

c. Laying the pipeline on the ground

On the ground, the pipes will be connected together at flange intervals of 24 m. Before placing the pipes on the pipeline supporting foundations, the 6 m pipes will be welded together to a length of 12 m and flanged on one end. The 12 m pipes flanged on one side will be placed on the foundation so that the unwelded ends will face each other and then welded together. The pipe joints to be welded on the site should be once in every 24 m. As for each outlet nozzle of drop tanks, a 6 m long double-flanged pipe which is lined with rubber should be fitted.

The drop boxes between K - J in Section 8 will be connected by pipes in the same manner as the drop tanks.

(3) Common precautions for pipeline laying

a. Great care is needed in protecting the pipe ends from damage.

b. When lifting the pipes down from the truck, place wood sleepers on the ground to prevent the entry of earth and pebbles into the pipes. Before laying or jointing the pipes, make sure that their inside is free from any foreign matter.

c. Be sure that the flanges are welded strictly at right angles to the axial center line of the pipes. In welding the pipes on a straight line, their positions should be so adjusted that the axial center lines of the adjacent pipes form a strictly straight line before they are welded together.

d. In welding the butt joints of pipes, it is necessary to select suitable groove shape and welding method so that relatively smooth root beads are obtained on the inside (back beads). Excess beads formed on the inside will greatly increase the wear of pipe in this part.

e. Hydraulic pressure test of pipeline

After the installation of pipelines of each section, they shall be subjected to the water leak and hydraulic pressure tests. The test pressure will have to be 15 kg/cm^2 at most.

f. Since the pipes are estimated to have a usable life of about three years, they should not be painted.

9.3 WORKS APPURTENANT TO LAUNDER LINE AND PIPELINE

9.3.1 Emergency Pond

(1) No. 1 Emergency pond

This pond will be constructed in the swamp where the portal at the pont J near the terminal of the launder line in the tunnel is to be located. The specifications for the pond embankments and required facilities are shown in Paragraph 7.4.10 and Fig. 7-15.

In this work, the bottom culvert (water intake culvert) should be built in advance to the filling work on the embankment. The culverts are to be built with reinforced concrete. It is necessary to build a road for use in the construction of the emergency pond while the access road to the portal at the point J is in progress. Since the pond embankment is built with the muck produced in the tunnel driving in Sections 7 and 8, the bottom (water intake culverts) should be completed before the commencement of the tunnel driving work. After completion of the culverts, the construction work on the embankment will be continued, filling and rolling the earth fill that is brought from the tunnel, until the tunnel driving work in Section 7 is completed. The amount of earth fill required in building the emergency pond embankments is approximately 25,000 m^3 and the amount of muck produced in Section 7 is approximately 19,200 m^3. The muck will be produced in the form of large-grain gravel and broken rock. Great care is needed in doing the embankment filling work during the rainy season. When it is impossible to do the filling work due to the rain, the muck will be transported to the coastal area and the work will be resumed during the dry season. The road built for the construction of the emergency pond will be used as a patrolling road after completion of the pond.

(2) No. 2 Emergency pond

No. 2 emergency pond is to be built near the terminal of the launder line in the flatland area. Since there is no topographically suitable site in this area, the ground will be excavated to build the pond. The specification for the pond embankment are given in Paragraph 7-4-10 and Fig. 7-16. Since the earth close to the ground surface is to be used in building the embankment, it should be well rolled and compacted.

9.3.2 Emergency Water Supply Facilities

There is the necessity for emergency water supply facilities to supply the water requirement when the amount of slurry in the common line decreased and for washing the inside of the pipeline.

(1) Water intake from the Pellemell Creek

A water intake facility will be set up at the upstream of the Pellemell Creek between the points (G - H) in Section 6 and approximately 200 m long pipeline 500 mm in diameter is to be laid so that the water may flow due to its natural head to the portal at the point H where it will be fed to the launder line. The Pellmell Creek is a steeply walled valley and never runs dry even in the dry season.

Alongside the 500 mm-diameter pipeline, another pipeline 125 mm in diameter will be laid, thereby to deliver water through the tunnel to the emergency tank set up at the point L. The emergency tank made of reinforced concrete will have a capacity of 150 m^3. It will be used to supply water to be required in washing the pipeline between the point L to M.

The 125 mm-diameter pipeline in the tunnel can also be used to deliver the water required in preparing concrete when there arise the necessity of making repairs to the launder line installed downstream from the point H.

(2) Water intake form the Apangat River

A water intake will be set up on the west bank of the Apangat River to obtain water to supply the pipeline down from the point O. The pump will have a capacity of 36 m^3/min. and the water lifted by this pump will be caused to fall direct into the drop fall at the point (N - O). The pumping pipeline will be 600 mm in diameter and approximately 200 m in length.

9.4 CONSTRUCTION SCHEDULE

9.4.1 Preparatory Works (See Table 9-3)

There is a necessity for such preparatory works as the launder blocks prefabrication plant, access road to the work site, building of pipeline bed, etc.

The work on the access roads should be started simultaneously with the common line construction work. The access road construction includes the widening of existing roads and the construction of new roads. The widening of the existing roads to the site of the launder line will require approximately two weeks and the construction of new road approximately one month. The widening of the existing road leading to the site of the pipeline will take three weeks and thereafter the work on the pipeline bed and the construction of new road will be carried out at the same time. These works are estimated to require approximately four months, excepting the days when no such work can be done during the rainy season.

9.4.2 Laying of Launder Line

There will be two types of launder line laying works, that is, laying the launder line inside the tunnel and laying on the supports. The work of laying the launder line inside the tunnel should be started as soon as the tunnel excavation workis completed in each work section. A team of workers to be engaged in the foundation work, transportation, laying and surveying should be formed for each section. The foundation work will take approximately one month for each section.

The amount of time required for the launder line laying work will vary with different work sections, ranging from 40 to 70 days on the one-shift-a-day basis. Since it is impossible to secure a space sufficient to store a large quantity of launder blocks at the portal, the launder blocks should be transported as the launder line laying work progresses. If the launder blocks are transported only during the daytime, considering the conditions of the Kennon Road, with the starting point near Rosario, five trucks will be needed for hauling the launder blocks required for one work section. And the number of days required will be 30 to 40 days for Sections 1 through 6 and 15 to 20 days for Sections 7 and 8. Therefore, it will be possible to match the transportation of launder blocks with the progress of the launder line laying work. However, in consideration of the condition of the Kennon Road, the efficiency of transportation will possibly be decreased greatly during the rainy season, and therefore it is considered necessary to make proper arrangements so that the work of laying the launder line in the tunnel can be done during the dry season.

Outside the tunnel, the launder line should be laid on the supports after completion of concrete placing for the launder line support foundation and the erection of the launder line supports. Approximately 3,250 m^3 of concrete will be required in the construction of the launder line support foundation and approximately 2,200 tons of steel material will be needed for building the launder line supports. The launder line support construction work will require approximately one year and ten months.
The launder line to be laid is 4,700 m long, however there will be an ample margin of time to complete the work if the launder blocks are laid down one after another on the supports as soon as the latter are erected.

Of the sections of the pipeline, it is probably impossible to start the construction work on the bridge over the Bued River during the period from June to September when the river will be floodded. The bridge construction work will need approximately 1,200 m^3 of concrete and approximately 510 tons of steel material and will take approximately two years to be completed.

The work of laying the pipeline on the bridge will be completed within approximately one month. As for the work of laying the pipeline inside the tunnel in Section 11, approximately three months will be needed for the foundation construction and approximately two months for laying the pipeline after completion of the tunnel driving work. With regard to the work of the pipeline foundation and the support foundation works in Section 12, approximately one year will be needed. The work of erecting the pipeline supports and laying the pipeline will be carried out in the three areas into which this work section are to be divided and approximately three or four months will be taken to complete those works. Construction schedule of launder line and pipeline is shown in Table 9-3.

9.5 CONSTRUCTION COST ESTIMATION

9.5.1 Conditions of Cost Estimation

The costs of construction have been calculated on the basis shown on Table 1-1.

9.5.2 Unit Costs and Quantities of Principal Materials, Equipment and Labor Costs

Table 9-4 and 9-5 show the unit costs of principal materials, equipment and labor costs which are used in the costs estimation. Quantities of materials are shown in Table 9-6.

Tab 9-3 Construction Schedule of Launder Line and Pipe Line

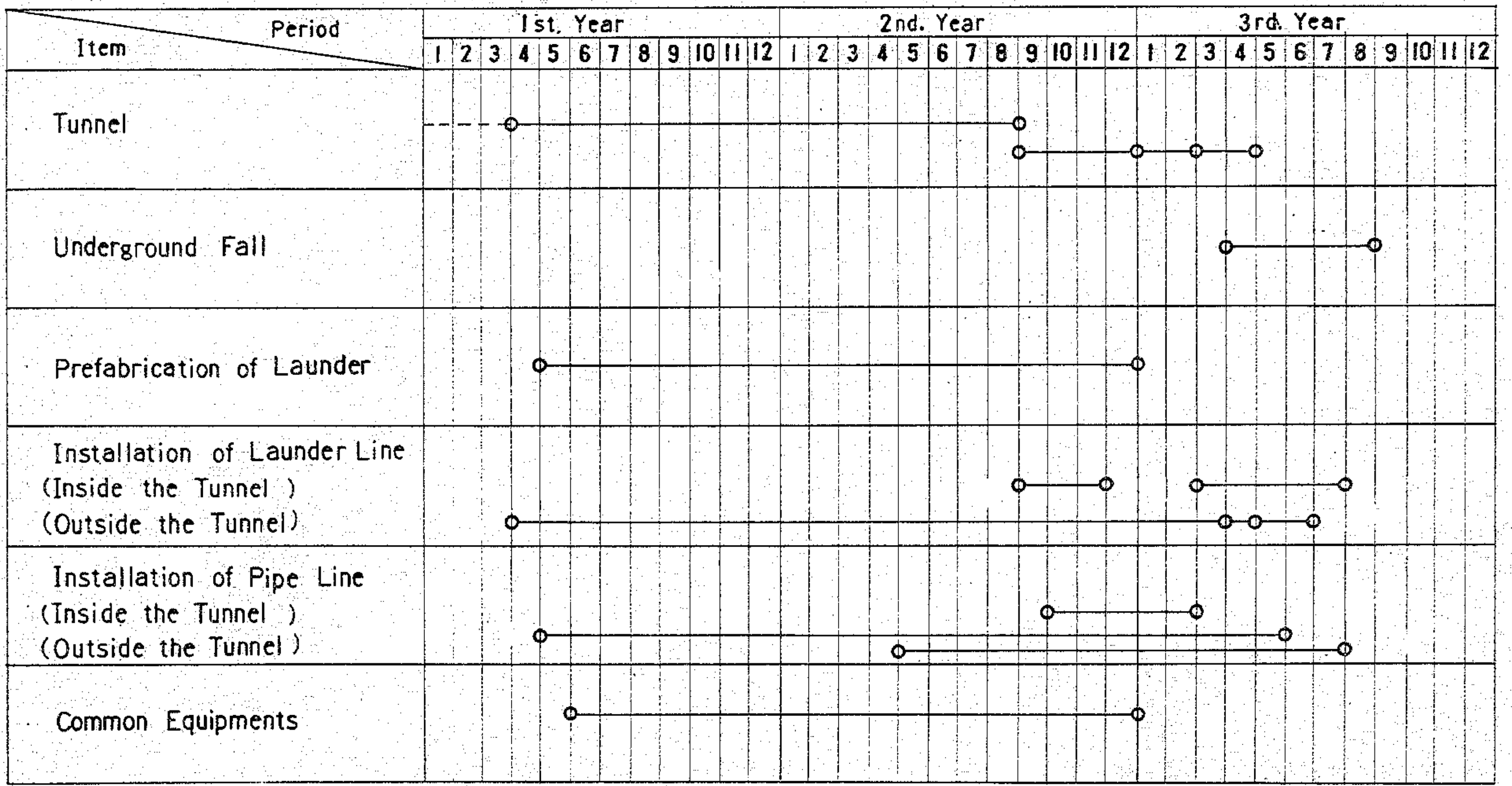


Table 9-4 Unit Cost of Principal Materials and Equipment

Materials	Cost	Remarks
	unit : Peso	
Steel		
Round Bar	2,300/ton	
Channel Steel	3,000/ton	
Angle Steel	3,000/ton	
Steel Plate	3,000/ton	
Cement - Portland	15/40 kg (bag)	
Wood		
Plate	1,200/m^3	
plywood	47/sheet	1/2" x 4' x 8'
Square Timber	2.0 bd.ft	
Aggregate		
Sand	30/m^3	
Gravel	50/m^3	
Oil		
Gasoline	1.6/Liter	
Diesel Oil	1.3/Liter	
Lubricant Oil	5.5/Liter	
Equipment		Include; rental, fuel, & labour
Bulldozer 90 - 120 HP	120/Hour	
-"- 120 - 170 HP	170/Hour	
Trucktor Shovel 0.8 m^3	110/Hour	
Truck 8 ton	80/Hour	
Truck-Crane 10 ton	90/Hour	
-"- 20 ton	130/Hour	

9.5.3 Construction Costs For Different Types of Work

Table 9-7 below shows the approximate unit cost of the various types of work for the launder line and the pipeline.

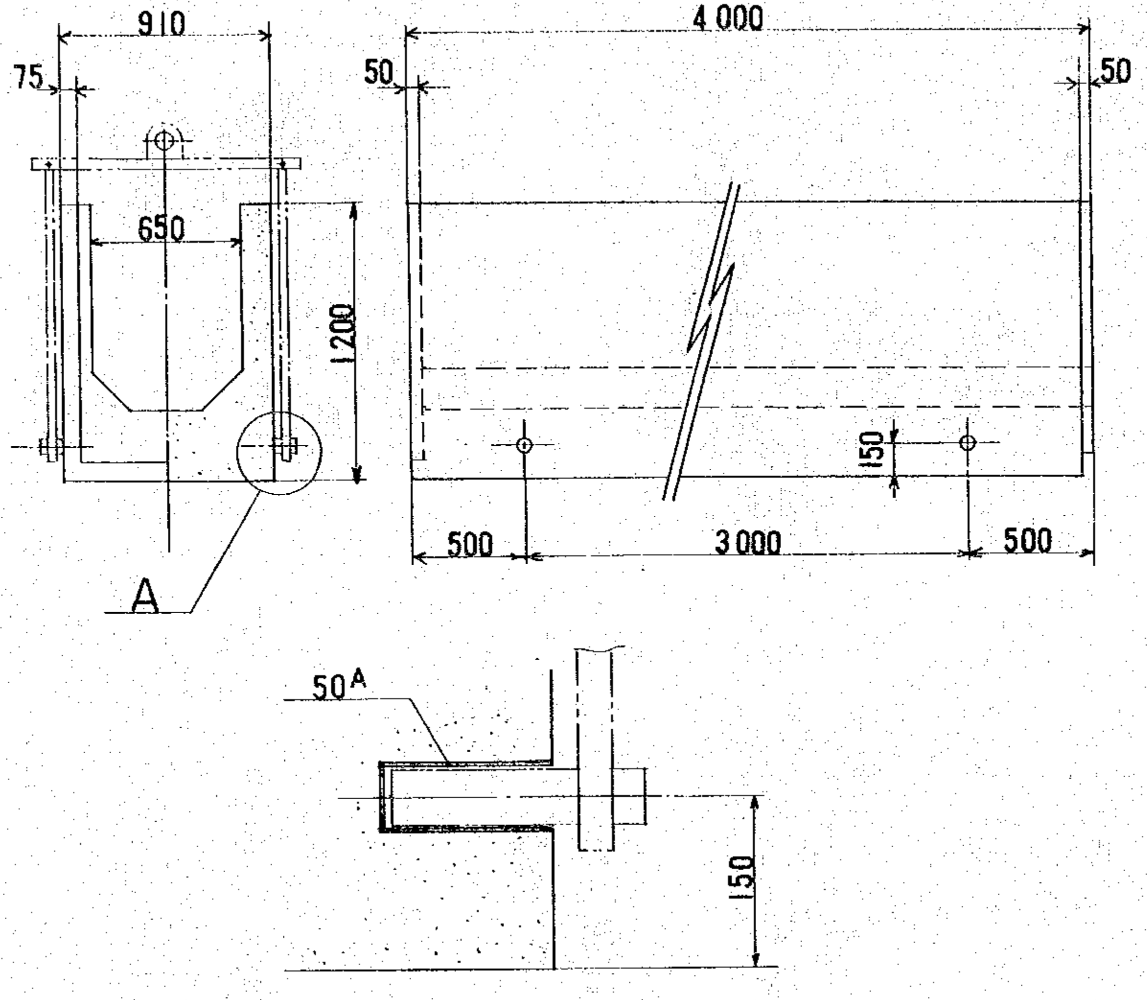
Table 9-7 Unit Cost for Different Types of Work

Water section	Work section	Cost	Remarks
Lauder line	In the tunnel	₱ 960/m	L=15,000 m Cost of tunnel driving given in Chapter 8
	On the supports	₱ 4,950/m	L=4,700 m
Pipeline (2 rows)	On the bridge	₱ 14,500/m	Bued River. L=600 m
	In the tunnel	₱ 3,700/m	L=1,100 m
	On the foundations outside the tunnel	₱ 3,990/m	L=3,100 m
	On the supports outside the tunnel	₱ 4,240/m	L=1,400 m
———	Drop box	₱ 116,000/m	5 sets
———	Drop tank	₱ 41,500/set	48 sets

9.5.4. Construction Cost of Lauder Line and Pipeline

Table 9-8 List of Construction Cost

Division	Item	Cost division		Cost (₱)
		Domestic (₱)	Foreign ($)	
Lauder line	Laying of lauder line (Manufacture and laying)	x 1,000 19,201		x 1,000 19,201
	Appurtenant works (Supports, bridge drop boxes)	x 1,000 22,937		x 1,000 22,937
	Preparatory works (Access roads, etc.)	x 1,000 2,919		x 1,000 2,919
	Total	x 1,000 45,057		x 1,000 45,057
Pipeline	Laying of pipeline (Laying works of pipe, material)	x 1,000 11,827	x 1,000 1,747 x 1,000 (₱12,667)	x 1,000 24,494
	Appurtenant works (Pipeline bed, foundation, bridge, drop tank, crossing highways)	x 1,000 15,025	x 1,000 22 x 1,000 (₱ 163)	x 1,000 15,188
	Preparatory works (Access roads, etc.)	x 1,000 2,337		x 1,000 2,337
	Total	x 1,000 29,189	x 1,000 1,769 x 1,000 (₱12,830)	x 1,000 42,019
Common facilities	Operators management facilities	x 1,000 3,330		x 1,000 3,330
	Common sumps	x 1,000 351		x 1,000 351
	Emergency systems (Emergency pond, water supply facilities)	x 1,000 4,000		x 1,000 4,000
	Total	x 1,000 7,681		x 1,000 7,681
Total		x 1,000 81,927	x 1,000 1,769 x 1,000 (₱12,830)	x 1,000 94,757



A — Section

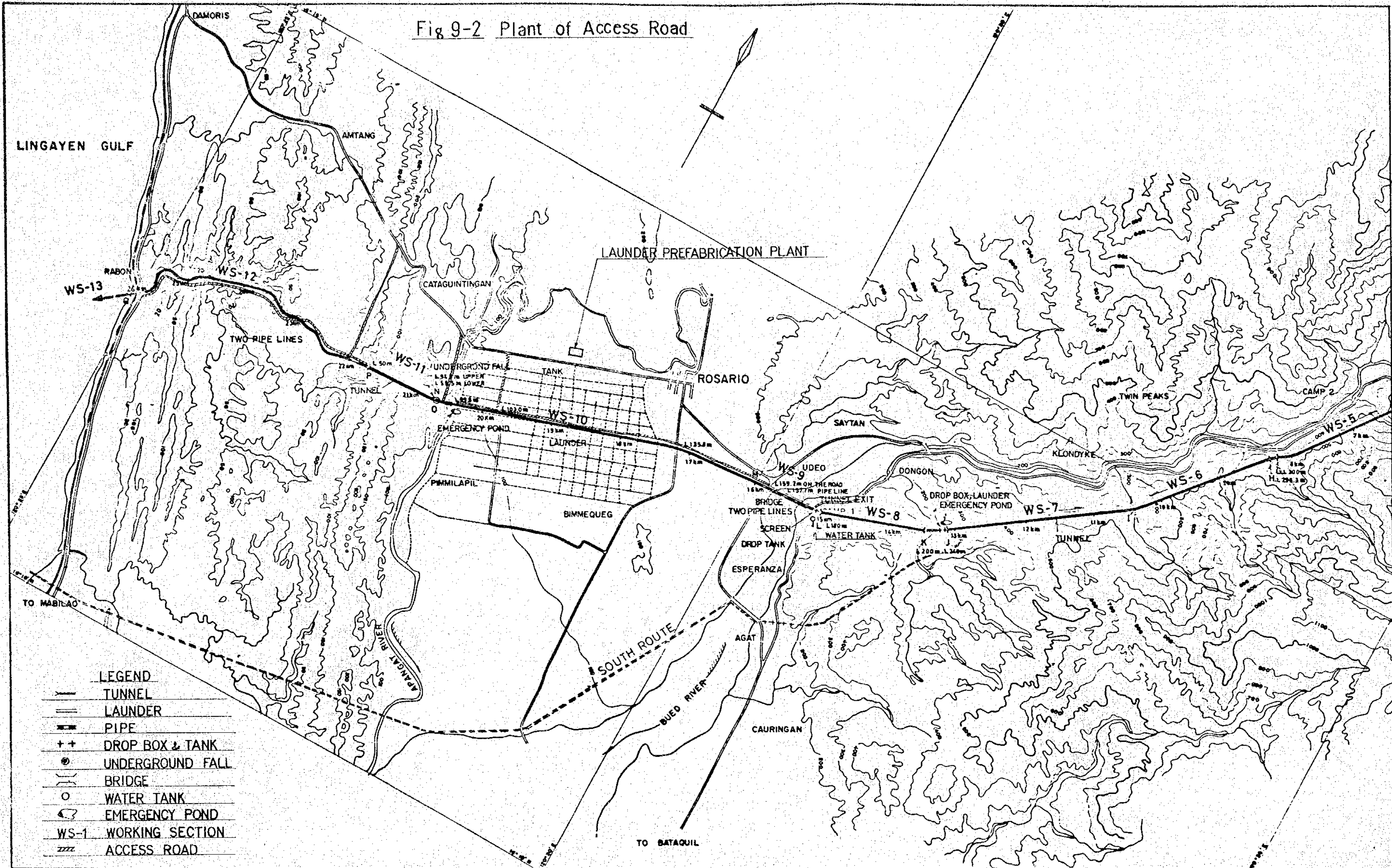
Fig. 9-1

Weight of Launder Approx 5.2 Ton

LAUNDER			
DRAWN BY	E.T	DATE	4/3/'78
CHECKED BY	K.S	DATE	4/3/'78
SCALE	1:30		

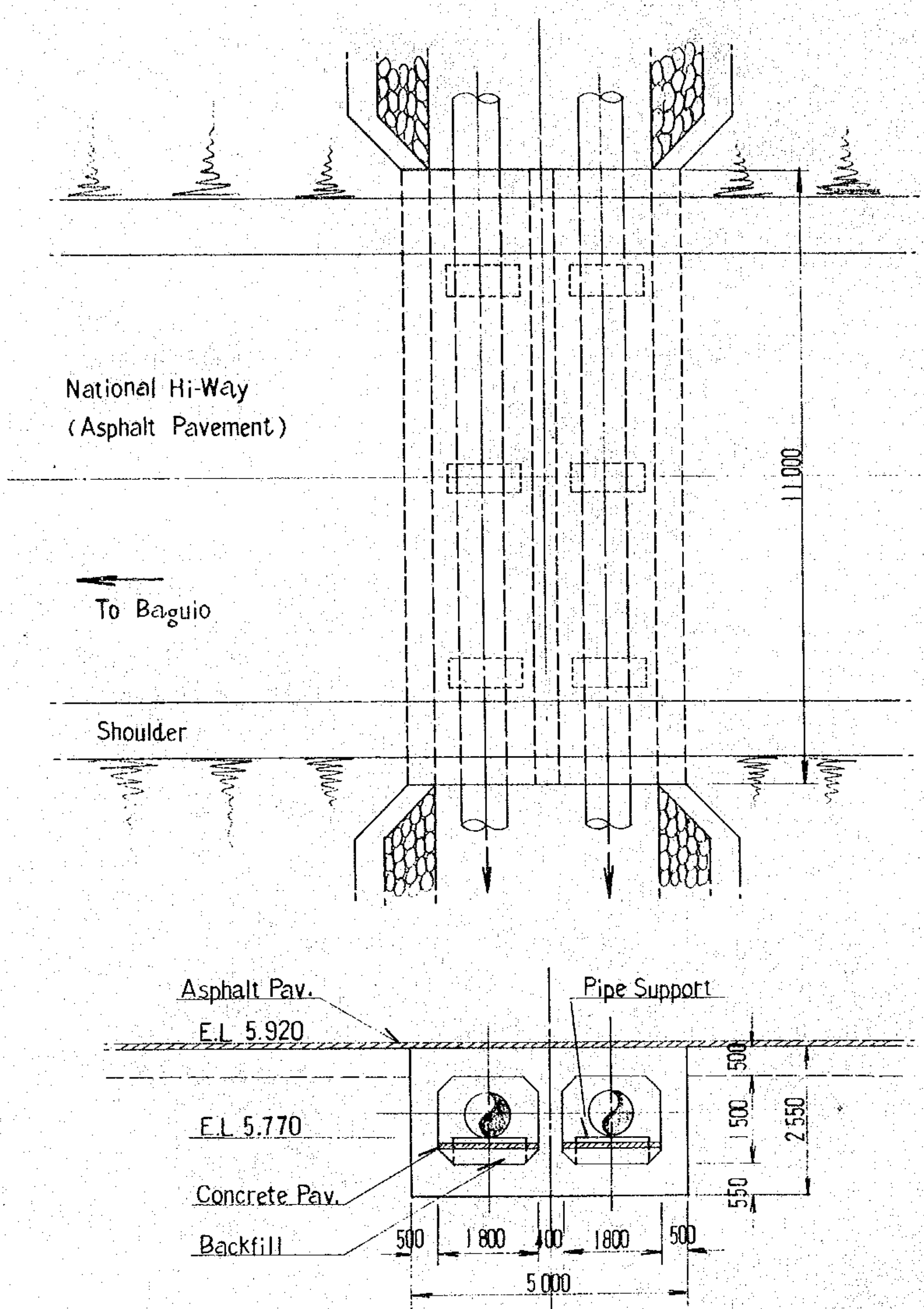
Unit : mm

Fig 9-2 Plant of Access Road



LEGEND

(symbol)	TUNNEL
(symbol)	LAUNDER
(symbol)	PIPE
+ +	DROP BOX & TANK
(symbol)	UNDERGROUND FALL
(symbol)	BRIDGE
o	WATER TANK
(symbol)	EMERGENCY POND
WS-1	WORKING SECTION
(symbol)	ACCESS ROAD



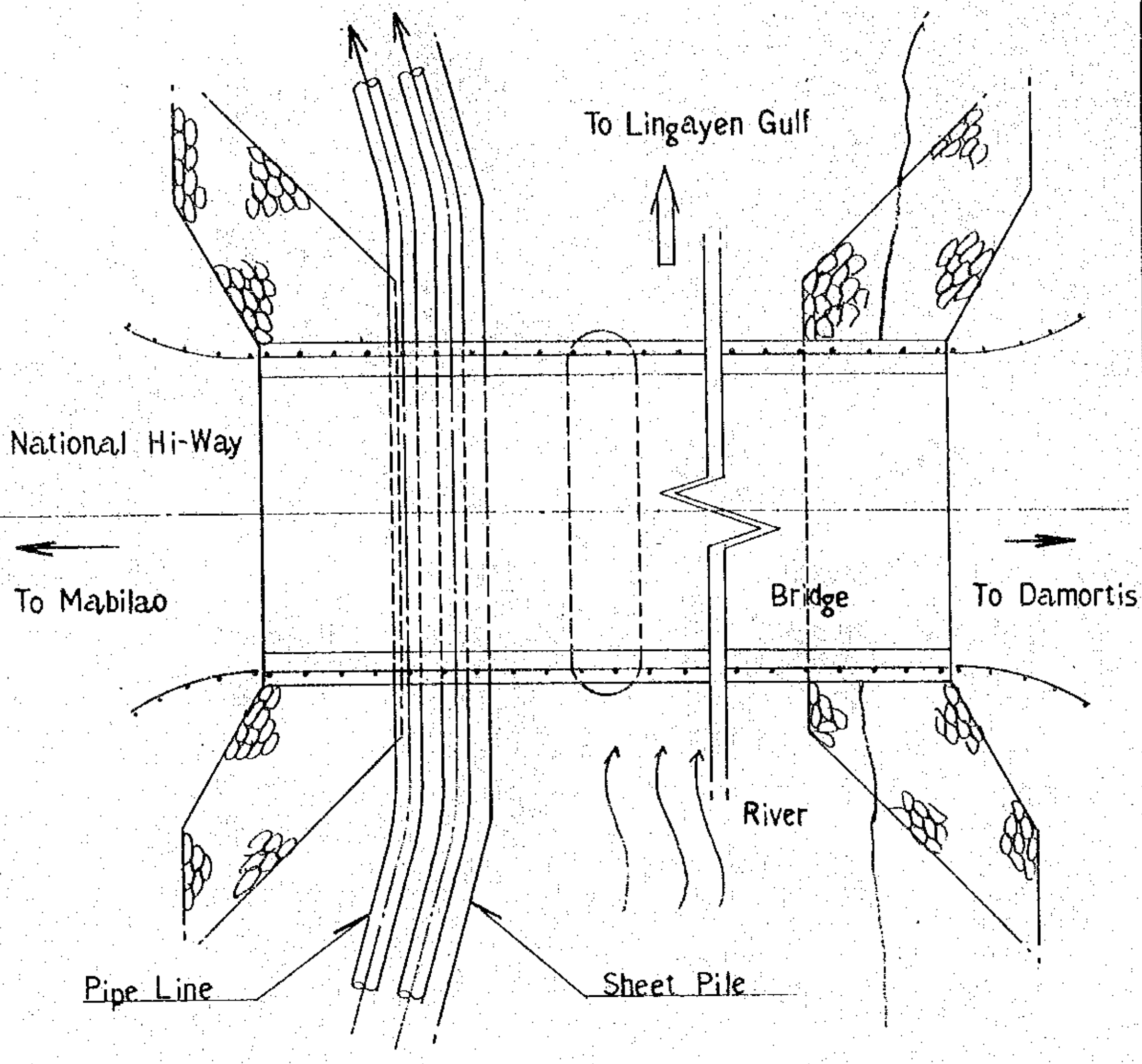
Location ; Udeo

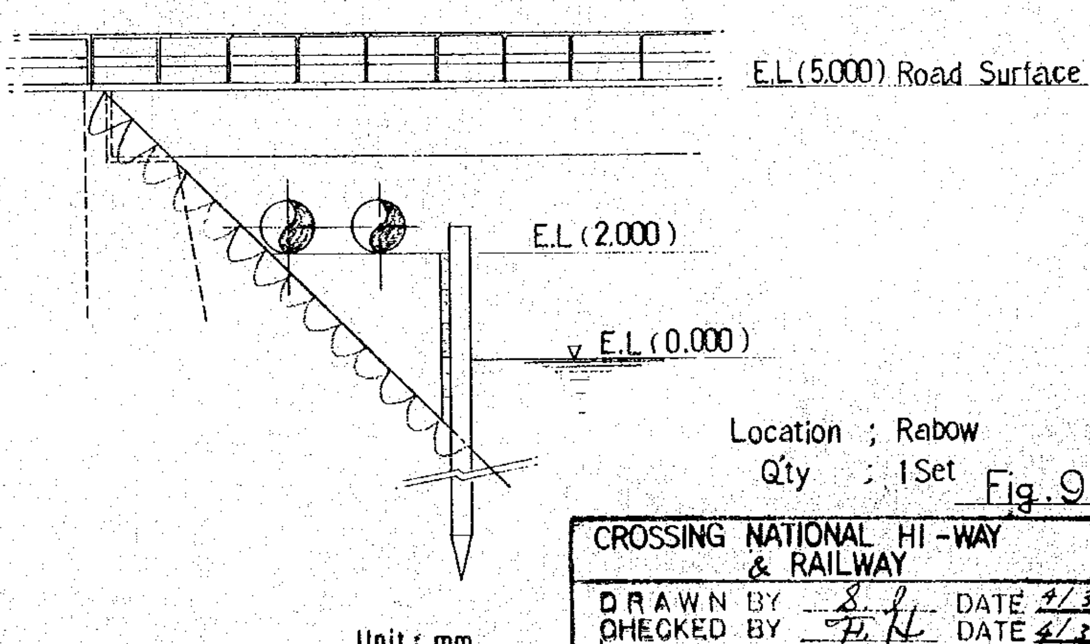
Fig. 9-5

CROSSING NATIONAL HI-WAY

DRAWN BY S. I. DATE 4/3/'78
CHECKED BY T. H. DATE 4/3/'78
SCALE 1:100

Unit : mm





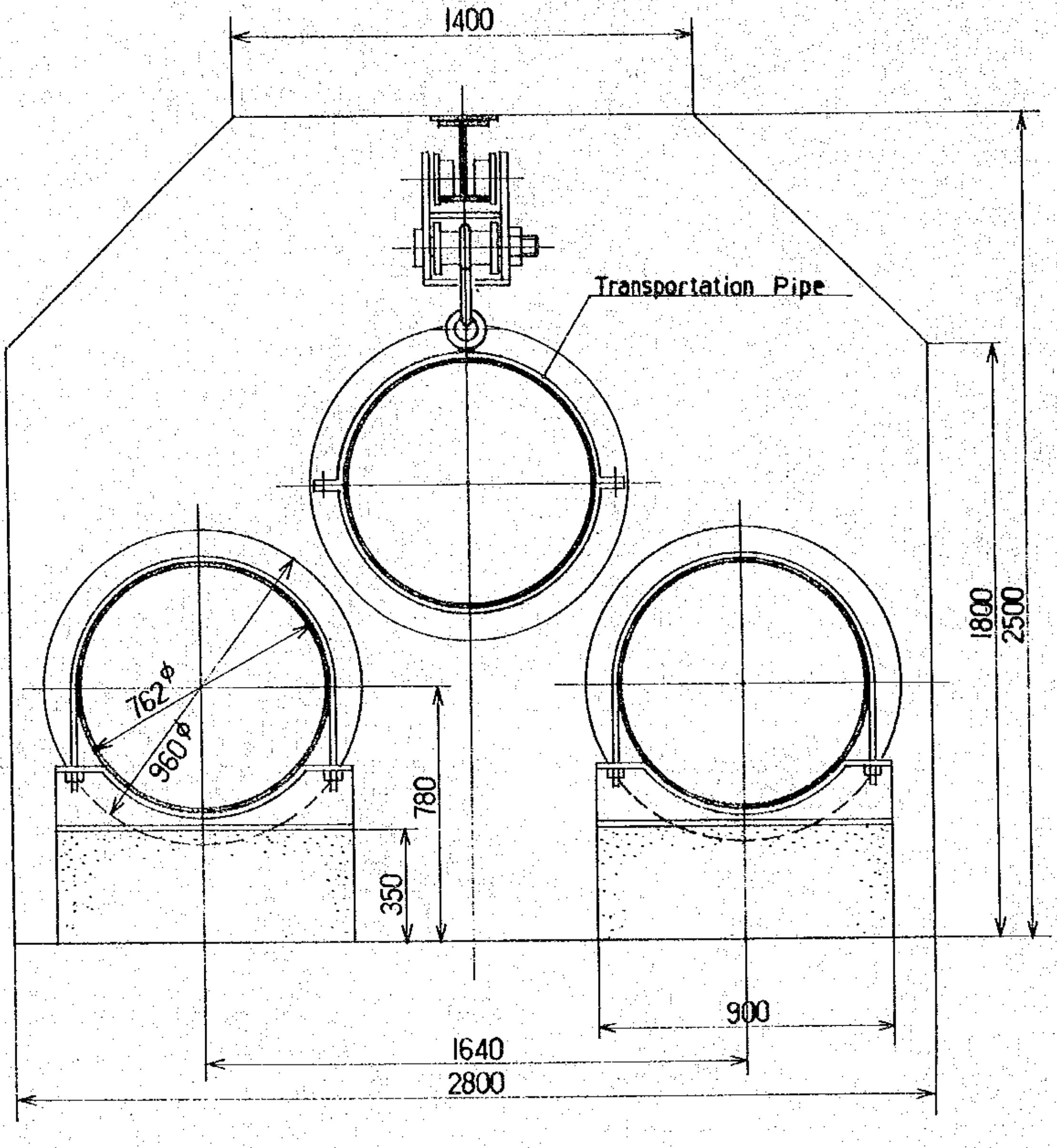
Location ; Rabow

Q'ty ; 1Set

Fig. 9-6

Unit : mm

CROSSING NATIONAL HI-WAY & RAILWAY			
DRAWN BY	S. J.	DATE	4/3/'78
CHECKED BY	F. H.	DATE	4/3/'78
SCALE	1 : 200	1 : 100	



Location ; WS -12

Fig. 9-7

TUNNEL SECTION

DRAWN BY	I. S.	DATE	4/3/'78
CHECKED BY	K. S.	DATE	4/3/'78
SCALE	1 : 20		

Unit : mm

CHAPTER 10

PLAN FOR COASTAL SECTIONS

CHAPTER 10

PLAN FOR COASTAL SECTIONS

10.1 BASIC CONDITIONS

For planning the flow-end disposal facilities (reclaimed bulkhead, etc.) along the coastal sections, the following figures will be used.

(1) Quantity of tailings to be disposed

Disposed quantity of tailings (per day)	35,000 t/day	t: DMT
Estimated years of the disposal	20 years	
Apparent specific gravity of tailings	1.8 t/m^3	
Total amount of tailings for reclamation	142,000,000 m^3	$\frac{35,000 \times 365 \times 20}{1.8}$

(2) Meterological conditions (see 4.3)

Max. wind velocity	30 m/sec.	Annual average: 2.5 m/sec.
Wind direction	Northwest	Annual most frequent wind direction: Southeast

(3) Oceanographic conditions (see 4.3)

Tide level	1.20 m	H.H.W.L = D.L + 1.20 m
Tide velocity	0.5 kt	Tidal direction is uncertain
Height of wave	2.7 m	1/3 significant wave
Cycle	5 sec.	

(4) Seabed conditions

Foundation of seabed	Sand ; N value > 30

(5) Design seismic intensity

Horizontal seismic coefficient KH	0.1	
Vertical seismic coefficient KV	0.0	

(6) Weight of materials used per unit volume

Reinforced concrete	2.45 t/m^3	
Steel	7.85 t/m^3	
Tailings	1.80 t/m^3	
Sea water	1.03 t/m^3	

(7) Technological characteristics of tailings

True specific gravity	2.7	
Specific gravity of slurry	1.3	
Inner friction angle		
Cohesion		
Repose angle	15%	supposed in water

(8) Standards to be conformed with

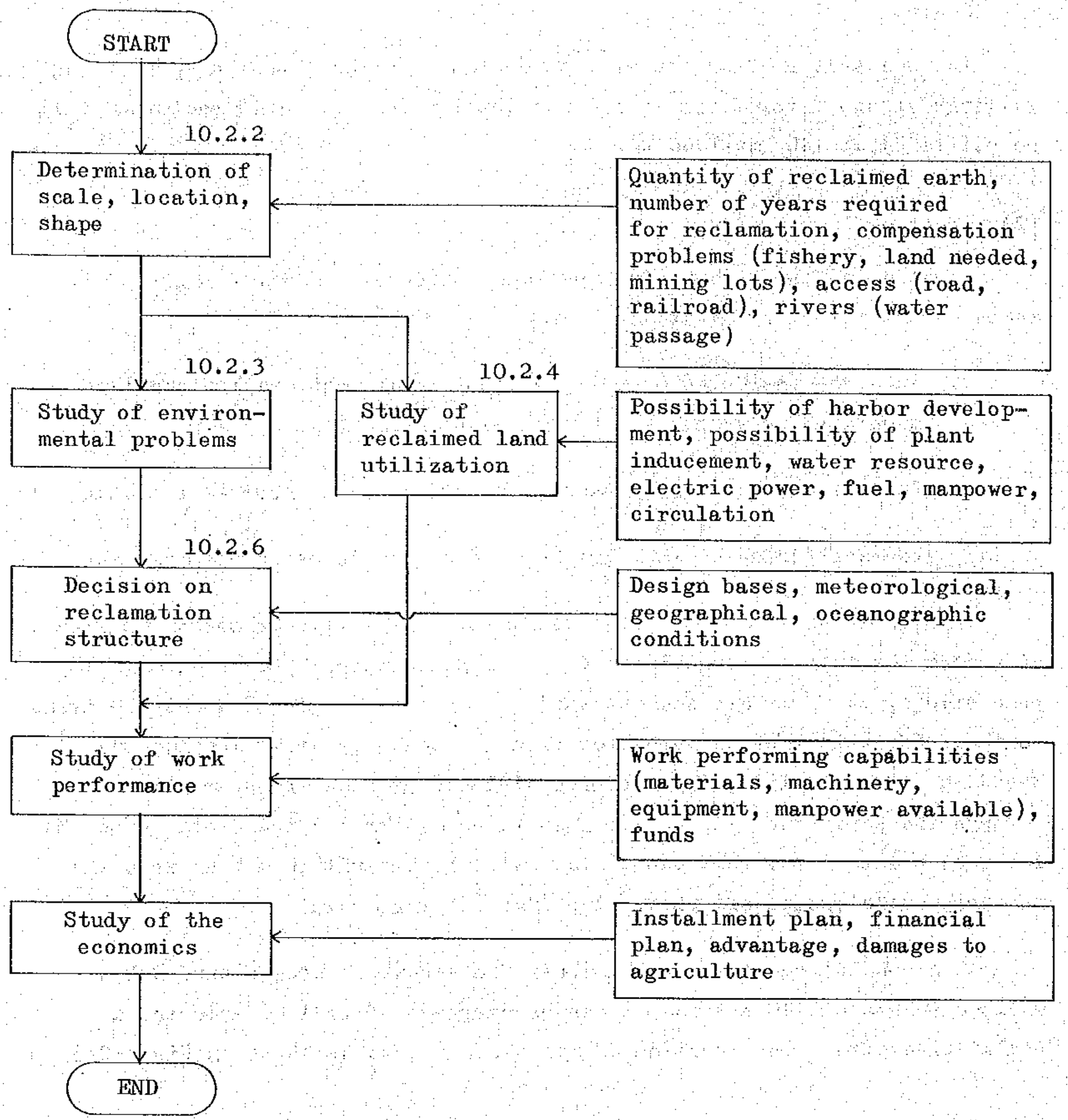
- Harbor structures design standards (Japan Harbor Association)
- Guides for marine steel structures designing (draft) and
- Guides for marine concrete structures designing and working (draft) (Japan Society of Civil Engineers)

10.2 STUDY OF RECLAMATION METHODS

10.2.1 Outline

The steps to be followed for studying the reclamation methods with the study subjects is shown in a form of flowsheet (Fig. 10-1).

Fig. 10-1 Reclamation Method Flowsheet



10.2.2 Study of scale, location, shape

(1) Scale

The scale of reclamation will be designed to the extent of permitting tailings disposal for 20 years and the total volume of earth reclaimed will be estimated at 140 million m^3.

(2) Location

In studying the location of the land to reclaim, attention should be taken on the following items:

i) An area considered most free from causing compensation problems should be selected.

ii) The extension of water passage should made as short as possible.

iii) The scattering of tailings be made by the force of natural flow.

In principles i) and ii), the reclamation land will be set in an area away from the inlets around Santo Tomas where culture, fishery using fish pond exists, sand bar areas where sand mining lots are located and the areas north of Damortis where a number of rivers, medium or small are running. Based on principle iii), the carrying distance by flow transportation through the pipe line will be designed to be 6.9 km and the distance to the farthest point of the reclamation land will be set within 6.9 km from the seashore outlet point of T.L.P. line (Rabon river mouth).

As a conclusion of the above-mentioned study, an area around Rabon where a volume of 140 million m^3 can be disposed of will be selected as reclamation site. The location of reclamation land is shown in Fig. 10-3.

(3) Shape

The shape of reclamation land (center line of the bulkhead) varies according to the bulkhead structure, type and the economy.

In studying the shape of reclamation land, attention should be taken on the following items:

i) Easy access from road and railway.

ii) The water passage from the river should be made as short as possible.

iii) The bulkhead center line of the offing side should be placed in an area with a shallower possible depth.

On the above-mentioned points, the shape of reclamation land will be determined by the following:

a. Determination of reclaimed land level

The reclaimed land level (GL) will be made at DL + 4.0 m for easy access from road and rail road,; with reference to the tide level of Manila Bay and Poro Point Port reclamation data (See Fig. 10-2).

b. Determination of bulkhead level

For the economics of bulkhead structures, the bulkhead level will be made at DL + 2.5 m, and protection against land erosion by waves will be provided with armor stone facing or similar means (See Fig. 10-2).

c. Determination of reclamation center line

The north-south bulkhead line (west bulkhead) increases its underwater depth towards the offing, and the bulkhead structure gets larger in its scale to raise the construction cost. This time four alternative shapes (plan A, B, C, D) are studied for comparison (See Table 10-1 and Fig. 10-3).

Table 10-1 Comparison of the Reclamation Shapes

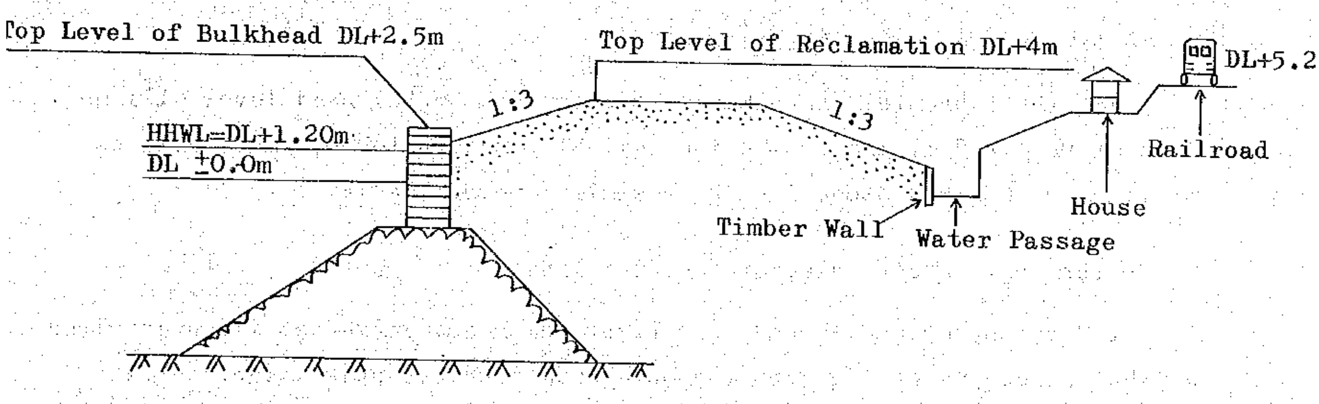
Spec. / Plan	Reclamation area (ha)	Volume ($\times 10^3$ m^3)	Bulkhead length (m)	Water passage (m)	Rubble volume for bulkhead ($\times 10^3$ m^3)	Rubble volume for corrugated pipe cell ($\times 10^3$ m^3)
A	1,413	143,775	11,700	4,000	5,106	2,095
B	1,300	142,000	10,450	1,200	4,679	1,963
C	1,260	143,700	10,400	700	5,105	2,328
D	1,190	142,800	10,500	400	5,514	2,635

The calculations of the rubble volume for the Bulkhead are shown in Appendix A-10-2-1.

i) In the case of rubbles type or cell type bulkhead, the cost of rubbles accounts for a large percentage in the total cost. Therefore, B plan, which is the smallest in the required quantity of rubbles for the same types, will be adopted.

ii) In case the bulkhead is constructed by filling tailings (methods 7 & 8 in Table 10-2), D plan, which has the shortest length of water passage, will be adopted.

Fig. 10-2 Schematic Section of Reclaimed Land



10.2.3 Study on Environmental Problems

Because of environmental changes caused by the land reclamation, it is important to adhere to the following points in deciding the location and shape of reclaimed land, bulkhead and working method to be used.

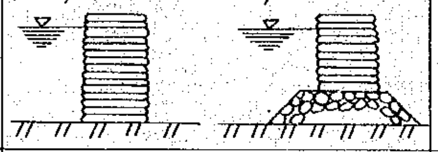
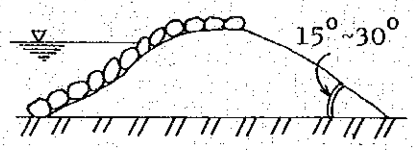
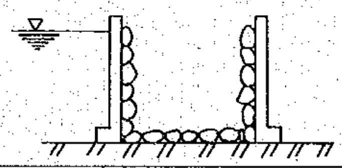
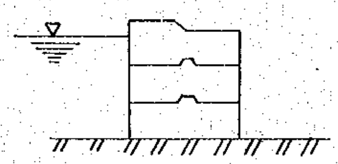
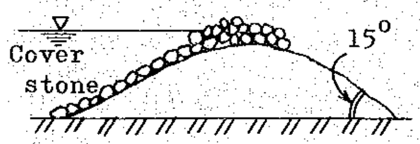
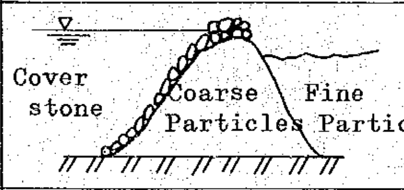
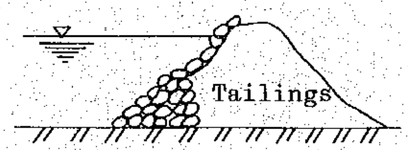
i) Anticipation of the tide and current changes caused by land reclamation.

ii) Anticipation of the turbidity diffusion in waters caused by construction work.

iii) Anticipation of the sea water contamination caused by tailings.

iv) Anticipation of the influence given to plants and animals by the phenomena as noted in i), ii), and iii).

Table 10-2 The Characteristics of Bulkhead Types

Method	Bulkhead types	Bulkhead structure	Cross section Bulkhead	Water Depth applicable to	Workability	Economics	Features
Closed Type	1. Sheet Pile type	1) Steel sheet pile 2) Timber pile		1) 10 m 2) 5 m	Shorter period of work Piling skill is needed	1) Costly 2) Not expen-sive	1) Perimit perfect sealing. 2) Limited in applicable water depth
	2. Rubble type (Rubble + coating)	1) Rubble 2) Rubble + Asphalt 3) Rubble + Mortar 4) Rubble + Sand 5) Rubble + Tailings		10 m	Work process is simple. with deeper depth of water, Cell of larger cross section is needed.	Somewhat costly	1) With deeper depth of water, the indices of economic get poor. Selection of coating is needed.
	3. Corrugated Cell type	1) Corrugated Cell 2) Rubble + Corrguated Cell		1) 5 m 2) 10 m	Foundation leveling for anchoring cell is needed. Shorter work period	low cost	1) Appropriate cell diameter can be used according to the conditions of foundation ground. Survey of the sea bed is needed
	4. Dredged sand type	Filled with dredged sand supplied from pump dredger.		5 m	Pump dredger is needed. Cross section is large, cover stone is needed.	Costly	A large volume of sand is needed. When a sufficient volume of sand is available, the total cost will not be high
	5. Cellular block type	1) Cellular block 2) Rubble + Cellular block		1) 5 m	Technique for ferro-concrete structure and leveling of foundation are need.	Costly	Working technology is required. Stable foundation is needed.
	6. Block type	1) Block 2) Rubble + block		1) 5 m	Manufacturing of con-crete block and leveling of foundation are required.	Costly	Same as above (5).
Open type	7. Raw Tailings type	Tailings		10 m	Large cross section, rubble placement on top is needed.	Low cost	Liable to be effected by waves and currents. Required to survey the amount of tailings which is carried away.
	8. Classified tailings type	Cyclone + tailings		10 m	Cross section is smaller than that of above (7), but cyclone is needed.	Low cost	Same as above, study has to be made for the production rate of tailings of coarser particle size.
	9. Rubble mixing type	Rubble + tailings		10 m	Smaller in cross section than above (7) and required quantity for rubble is also small	Somewhat cost	Less vulnerable to the force of waves and currents than above (7).

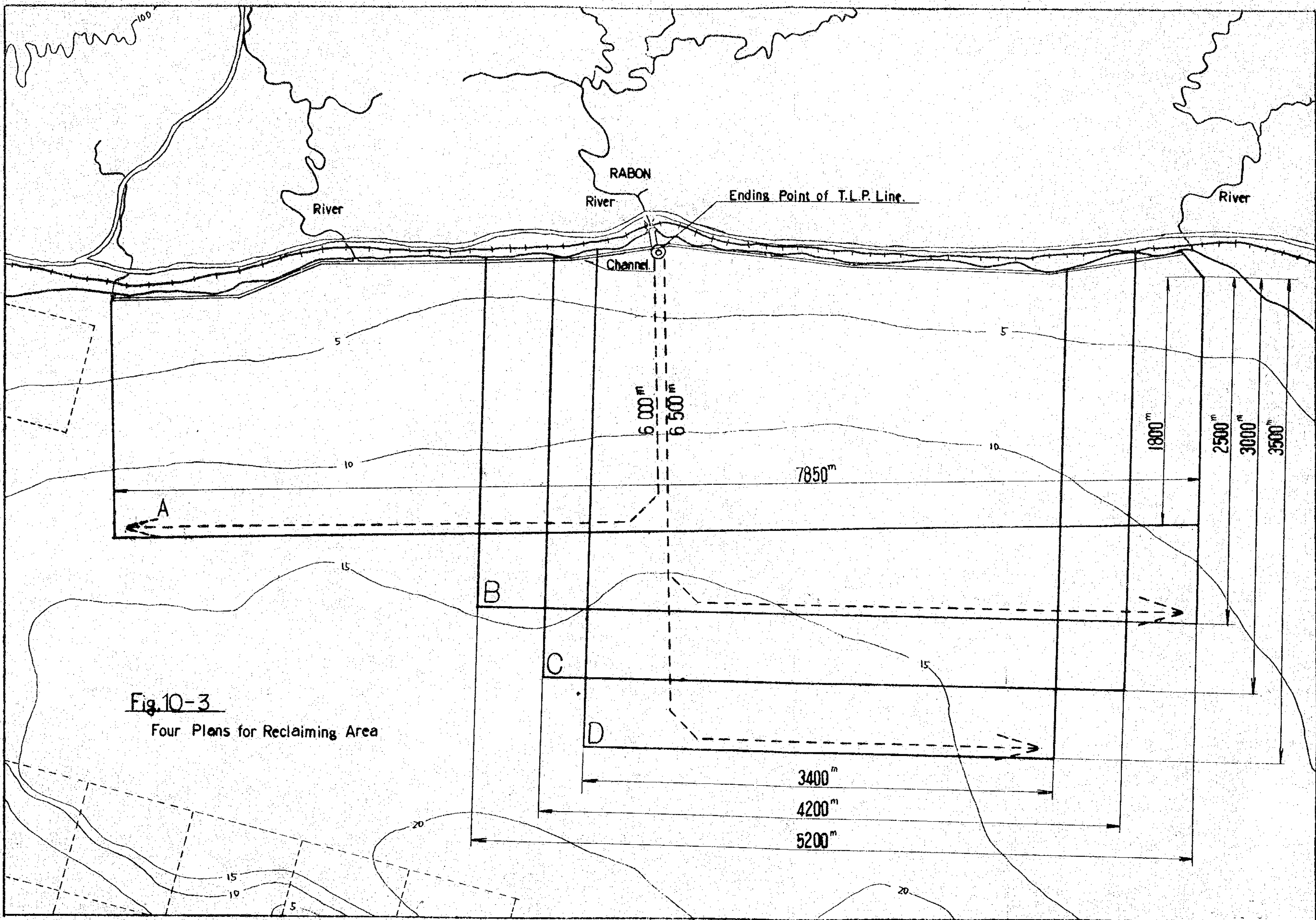


Fig.10-3

Four Plans for Reclaiming Area

In order to make accurately the qualitative and quantitative anticipation on the above factors (e.g., the range and degree of contamination), it is necessary to conduct an intensive study on the present state of environments, sea currents, seabed configuration, atmospheric conditions, and ecological system.

With regards to the intended environmental changes caused by the disposal of earth, tailings etc. in the sea area, the Philippine Government should conduct the assessment making reference to their environmental standards.

This report does not go beyond presenting some alternative plans on the reclamation methods.

As regards to the present state of marine environment (quality of sea water, seabed soil) in the Lingayen Bay, and the environmental standards in the Philippines and Japan, the data as shown in Appendix A-10-2-2, and the examples of mine tailings sea area disposal method taken at other mines in the Philippines are shown in Appendix A-3-2.

10.2.4 Study on Utilization of Reclaimed Land

When a quarter of land is reclaimed as marine disposal area at the offing of Rabon, the developed land could be utilized as harbor and seaside industrial areas. According to the land utilization plan adopted, consieration must be given to the types of bulkhead and adequate working program for construction. However, it is most desirable to determine the way of utilization in line with the Philippines' general economic development scheme. In the Report, the land reclamation plan is studied limiting the object on land to be reclaimed for the purpose of disposing the tailings.

As regards to the subjects considered necessary to be studied in case land reclamation is made in the future to use the developed land as harbor and seaside industrial areas, part of them is described in Appendix A-10-2-3 as referential data.

10.2.5 Study of Possible Impact to Economic Conditions (Fishery, Agriculture)

The fishermen who are involved in the sea area as referred in this Chapter, are those engaged in municipal fishing. It is necessary to study the fishery compensation problems which involve these people in connection with the reclamation. A description on the fishery condition in the area and estimated compensation amount is shown in Appendix A-10-2-4.

As regards to agricultural problem, that is the inceptive cause of this Project, the present state of agriculture economy around this area and the anticipated damage to agriculture are summed up in Appendix A-10-2-5 as survey result based on obtained data.

10.2.6 Study of Reclamation Structure

(1) General

In this Chapter, study is made of several ideas concerning the bulkhead types on the basis of the scale, location, shape of reclaimed land, the top height of reclaimed land and the height of bulkhead, which have been studied in 10.2.2. The conceivable bulkhead types are summed up in Table 10-2.

In selecting one type, consideration should be given to such factors as i) economics (construction cost, maintenance and management expenses), ii) performance (cutoff ability of tailings flowing out of the reclamation land and environmental problems), iii) construction workability, and so forth. In Table 10-2, the types of steel sheet pile (1-1)), dredged sand (4), cellular block (5), block (6), and mixed rubbles (9) are excluded from the objects for study from the angles of economics and workability.

As to timber pile type (1-2)) that is applicable within the water depth range of 5 m, it is examined for application as water passage bulkhead along shore line. In this Chapter, the types of rubble (2), corrugated cell(3), Raw tailings (7), and Classified tailings (8) are examined. The features of the above four types, are shown in Table 10-3.

(2) Rubble type bulkhead

The maximum water depth at the site of bulkhead is 16 m and the extended length of the bulkhead is 10,450 m. To fill up such a scale of

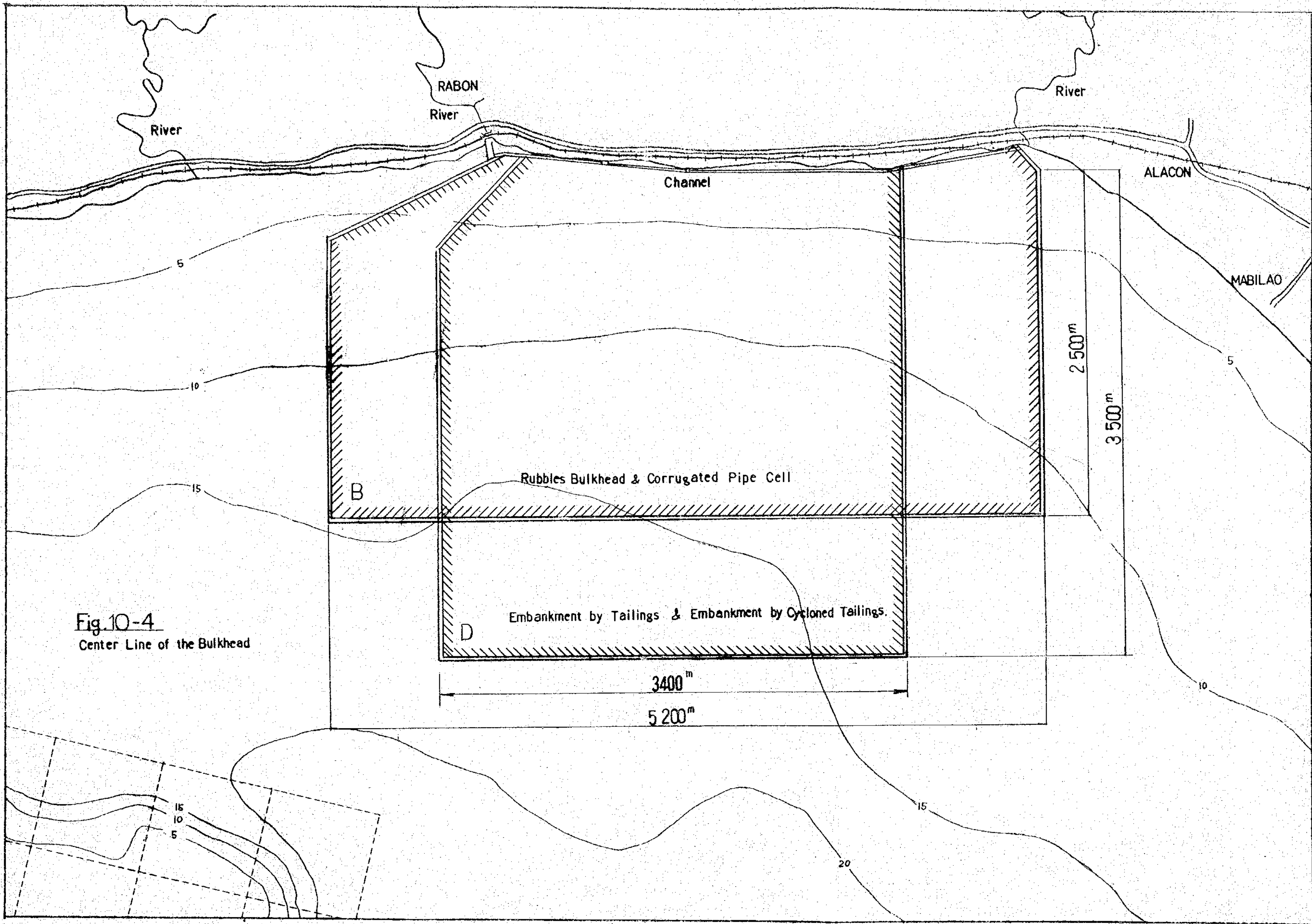


Fig.10-4
Center Line of the Bulkhead

Table 10-3 Comparison of Bulkhead Types

	Corrugated cell type	Rubble type	Raw tailings type	Classified tailings type
Explanation of methods	Pebble or sand is filled in corrugated cell to form bulkhead continously.	Rubble is cast in the place from carrier barge or dump truck.	Tailings are allowed to flow in the sea to construct embankment.	Embankment is constructed by using the coarse tailings selected by cyclone.
Economics	Corrugated cell has to be impored. Consumption of rubble is small. Low construction cost.	A large volume of rubble is needed. A little high construction cost.	Rubble is required only for use as cover stone. Less costly compared with the left two types.	Same as left. Cyclone has to be installed.
Performance of constructed bulkhead	No flow out of tailings.	Sucking out phenomenon of tailings takes place to some extent in the initial stage, but possibility of flowing out is nearly zero.	During the period until the time bulkhead construction is completed (several years), the flow of tailings is left in a natural flowing state involving marine contamination problems.	Same as left. Diffusion of fine tailings can be prevented.
Workability	Off-shore work by vessels is the main part of the entire work to be carried out. Work period is short.	Permits construction made directly from land. Necessary work period is determined according to the capacity of quarry and transportation.	Justification of adoption depends on oceanographic conditions (flow-out of embankment due to stormy weather).	Same as left. Complicate in pipe arrangement process.
Others	Division of construction plan will cause cost-up. Constructed part of bulkhead can be utilized as quay.	Division of construction plan will cause cost-up.	Cost is not much influenced by the division of construction plan. Bulkhead construction is started after T.L.P line completed.	Same as left.

bulkhead, an enormous volume of rubbles has to be supplied. Therefore, it is required to design a bulkhead with a cross section as small as passable.

In this case, a cross section as shown in Fig. 10-5 is designed. The required quantity of rubbles is 4,679,000 m^3. If the land is reclaimed into separate sections, the required quantity will be increased. The additional allowances of rubble in this plan is 20 per cent. Rubble bulkhead has openings in itself, through which tailings can flow out. Since these openings will be gradually clogged with tailings, coating treatment is not considered.

Quantity of rubbles	4,679,000 m^3 (additional allowance 20%)
Weight of armor stone	1.5 to 2.0 ton/piece
Gradient:	1:1.5 on the sea side
	1:1 on the shore side

The centerline of rubble bulkhead is shown in Fig. 10-4.

The stability calculation of rubble bulkhead, top height of embankment, and the weight of rubble are described in Appendix A-10-2-6.

(3) Corrugated cell bulkhead

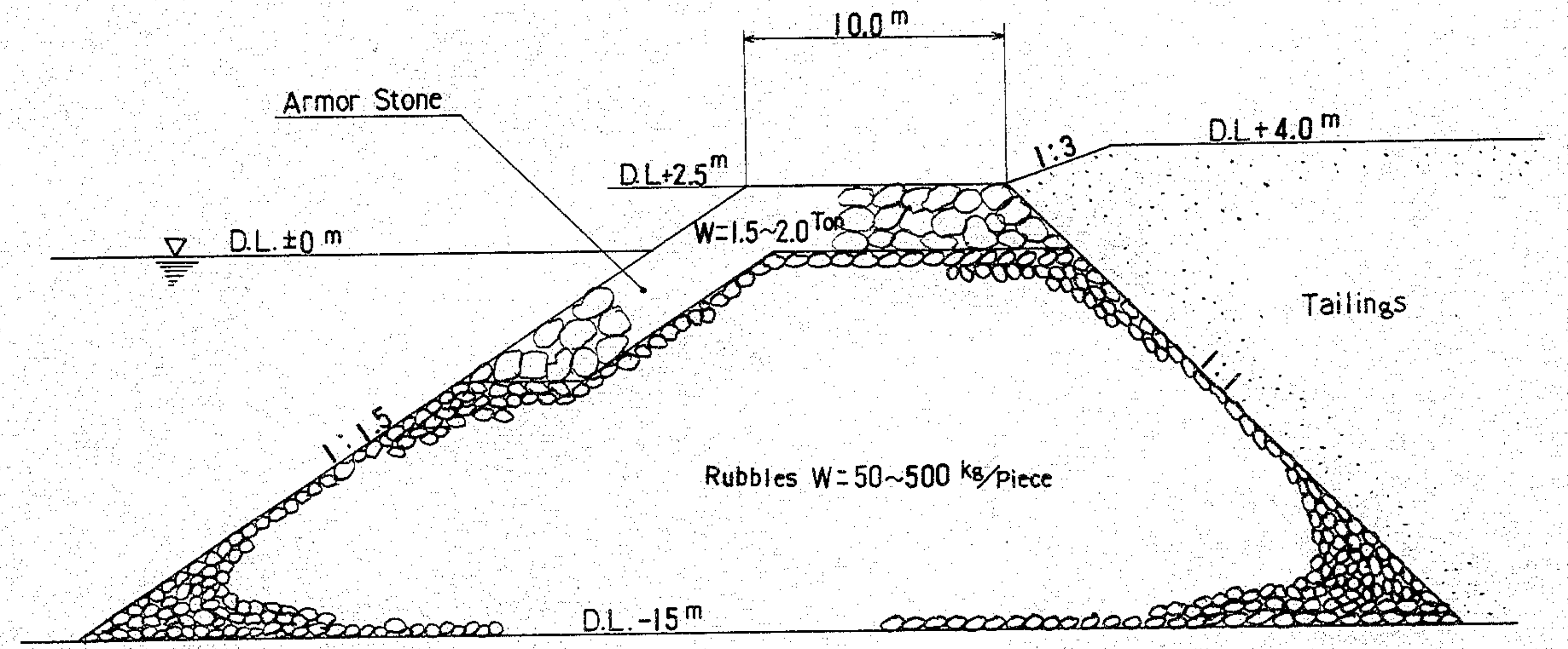
a. General

Corrugated cell type bulkhead is made up of arc-shaped sections formed with corrugated steel sheet pipes with sand filling. The arc-shaped sections are assembled with bolts at a place near the construction site and subsequently carried to the site for installation or are assembled at the construction site as bulkhead structure in which sand is filled.

For application to reclamation bulkhead, as mentioned later, there is a structural problem in relation to water depth. Because of this problem, this type of bulkhead is constructed with a part mixed with rubble bank structure and a part made up only with rubble as shown below.

i)	Shallower than DL - 5.0 m	rubble bank only
ii)	DL- 5.0 m ± 0.5 m	corrugated cell only
iii)	Deeper than DL - 5.0 m	bank of mixed structure

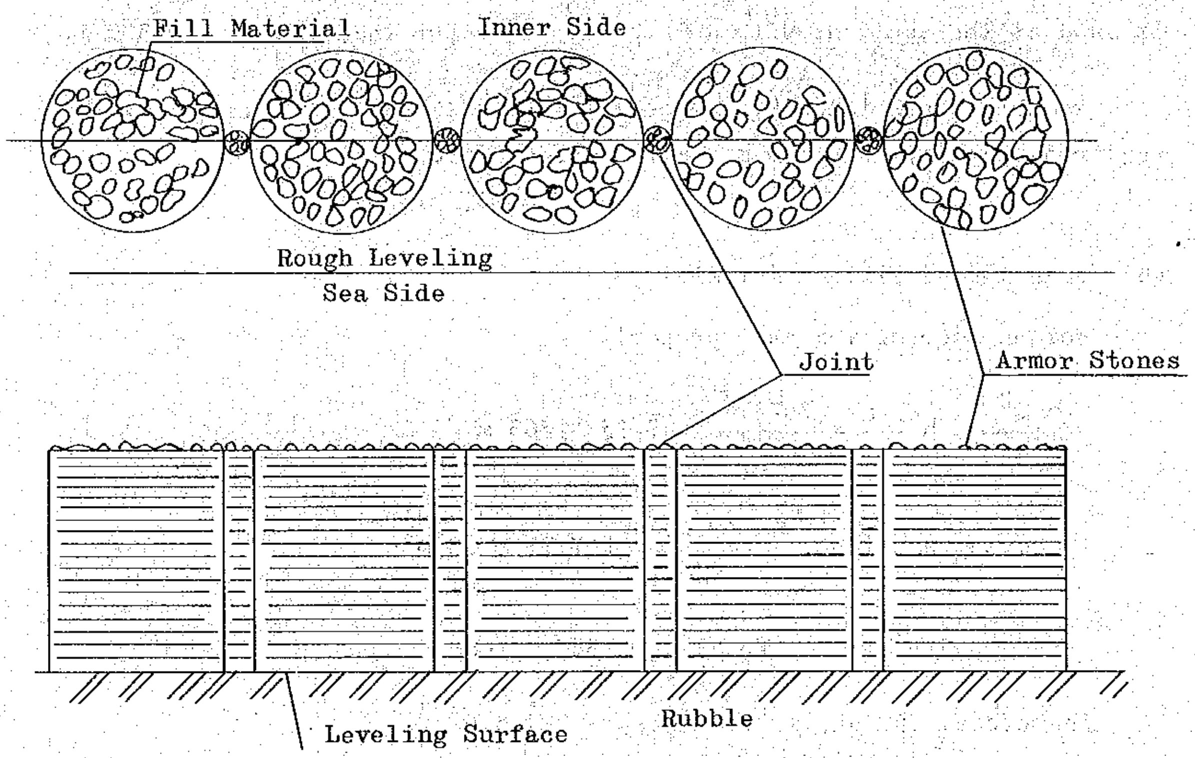
Fig. 10-5 Cross Section of Bulkhead (Rubble Type)



In this study, ii) is omitted from calculation due to lack of detailed water depth chart on the site. Required quantities are calculated on i) and iii) structures.

The bulkhead center line is shown in Fig. 10-4, which is the same as that of afore-mentioned rubble type bulkhead.

Fig. 10-6 Schematic Arrangement of Corrugated Pipe Cells



Corrugated cell bulkhead is widely used for land reclamation featuring its structural stability, simplicity of construction work that enables shortening work period, and muddy water retaining property.

With all such advantages, however, because of its cell structure, there arises a problem of member strength when used at low water depth, thus, requires a larger cell diameter, and the generally admitted size limit of its structure is 8.0 m in diameter and 7.0 m in height. As filling materials for cells, to provide for a stable foundation, sand or muck is used.

For Rabon tailings reclamation bulkhead, cells with a height of 7,750 m and diameter of 7,720 m will be used. The typical cross section is shown in Fig. 10-7, 10-8.

b. Required quantity of materials

(a) Cell quantity

The total length of cell bulkhead is 10,450 m that is obtained from Table 10-1. The aggregated length of the parts for which corrugated cell is used at the sections with a water depth deeper than 5.0 m is 9,300 m.

As the length taken by one cell in the bulkhead line is 9.72 m, the required quantity is 9,300 m ÷ 9.72 m/ea. = 956.8

≒ 957 pieces

(b) Quantity of filling material

For one corrugated cell proper,

$$\frac{\pi \cdot D^2}{4} \times H = \frac{\pi \times (7.72)^2}{4} \times 7.75 \fallingdotseq 363 \text{ m}^3$$

Joint sections $\frac{\pi \times (2.0)^2}{4} \times 7.75 \fallingdotseq 25 \text{ m}^3$

Total 388 m^3/ea.

Therefore, 957 ea. x 388 m^3/ea. = 371,316 m^3

(c) Leveling area

The total leveled area, including 1.0 m allowance on each side of front and back of installed cell, is:

(cell diameter + allowance width) x aggregated length

= leveled area

(7.72 m + 2.0 m) x 9,300 m = 90,396 m^2

(d) Foundation rubble

Based on the study made at 10.2.2, required quantity of rubble used for foundation is:

Fig. 10-7 Cross Section

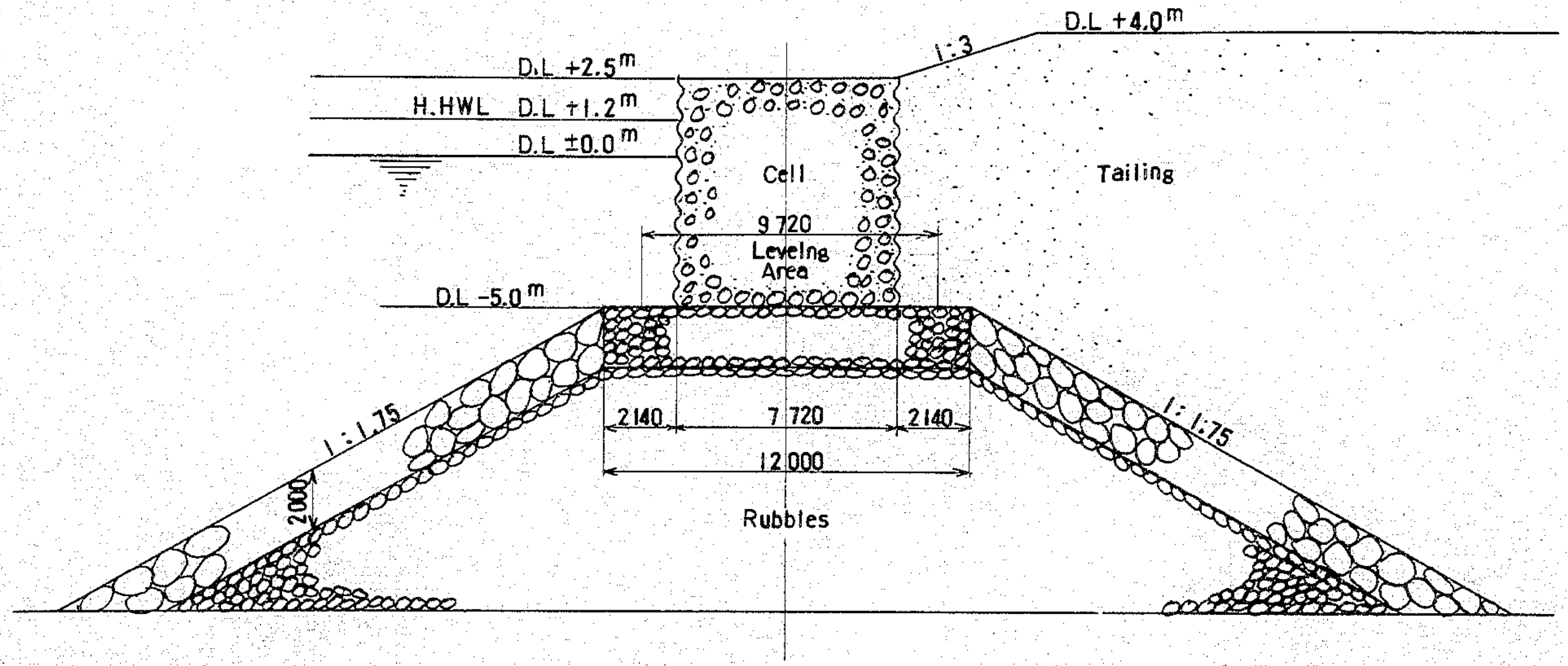
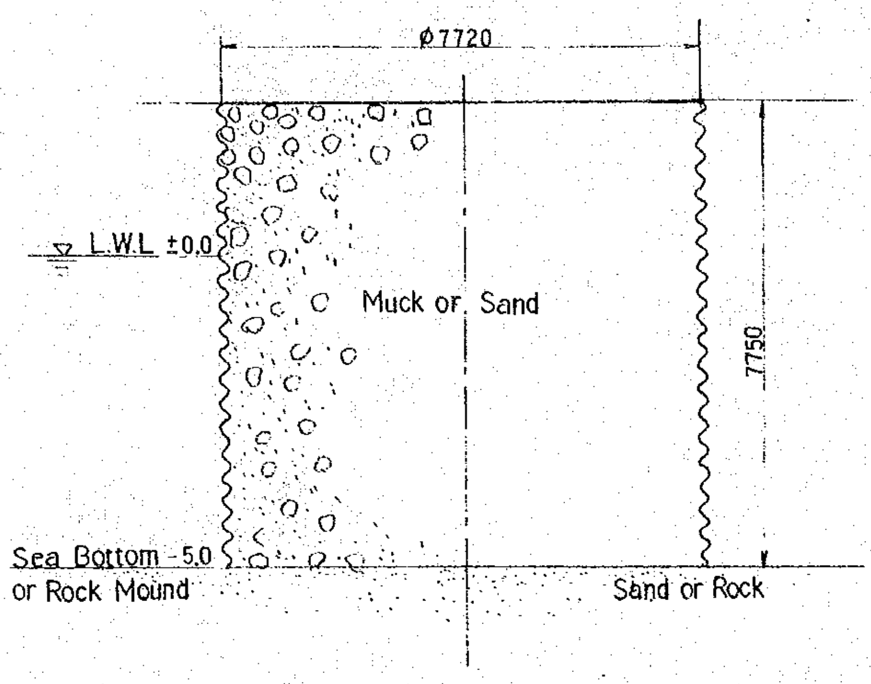
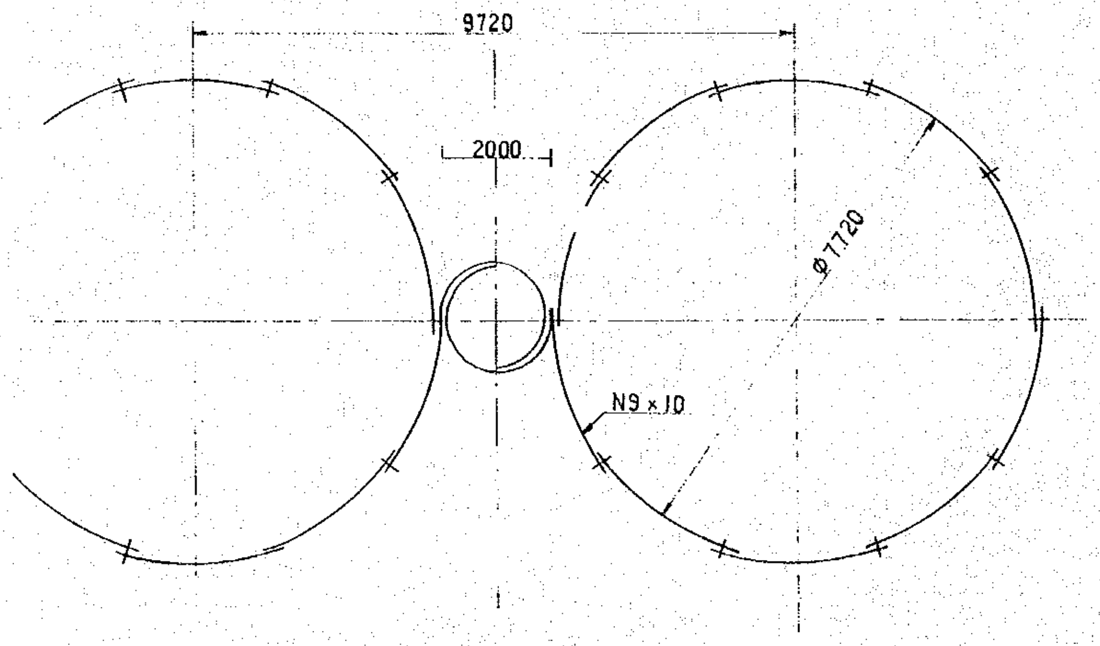


Fig. 10-8 CORRUGATED PIPE CELL II TYPE

Section



Plane



$1,963,000 \ m^3 \times 1.2 = 2,356,000 \ m^3$

(additonal allowance 20%)

No. of corrugated cell	Volume of fill	Area of leveling
957	371,316 m^3	90,396 m^2

Appendix A-10-2-7 shows the examination of designed calculation on Corrugated Cells.

(4) Raw tailings type bulkhead

This is a bulkhead which uses tailings carried through the pipe line on its construction. After the time the tulkhead is completed, the tailings are dumped into the bulkhead enclosure for reclamation and to eliminate contamination of sea water.

As to the repose angle of tailings, it is presumed to be around 20° which is the same as of Atlas. In the case of underwater deposition, the cross section gradient of tailings bulkhead should be decided on the assumption that the repose angle is approximately 15°.

As to the process of construction, bulkhead is built up by additionally connecting pipes to the preinstalled pipe line to advance after the ground level at the outlet rises up to the designed height.

Because of small particle size, much tailings are considered to be lost. However, no way could be done to estimate the lost volume. Generally the non-outflow volume of silt and clay will be below 70%. In this study 60% is assumed. The side slope will be provided with facing of armor stone.

On the cross section structure, as shown in Figs. 10-9, 10-10, rubble is used as support of pipes and a road will be provided widthwise.
In consideration of the possible intrucsion of rubbles into the tailings, the designed quantity of rubble is set at 30 per cent large than the calculated quantity based on the designed cross section.

Tailings volume for bulkhead	16,556,000 m^3
Rubble volume	364,500 m^3
Armor stone volume	1,463,000 m^3

The designed statement on weight and layer thickness of armor stone is given in Appendix A-10-2-8.

(5) Classified tailings type bulkhead

This type of bulkhead is constructed by using coarse tailings separated by means of cyclone from the tailings carried through the pipe line at the outlet.

The classified fine size tailings are deposited inside the bulkhead.

The proportion of underflow and overflow tailings classified by cyclone is estimated at 70% and 30% respectively. The separated tailings can be transported to a distance of about 20 m for underflow and about 500 m for the overflow.

Therefore, overflow tailings which are liable to pollute the surroundings, should be carried through a pipe into a place deemed as safe as possible from giving ill influence by its diffusion.

The cross section structure of bulkhead is the same as that of tailings type bulkhead and the repose angle of tailings is considered to be about 15°. The height is designed to be DL + 3 m, on which rubble is laid up to an even height of DL + 4 m and rails are fixed on the rubble foundation to permit travel of carts loaded with cyclone.

The yield ratio of tailings and the additional ratio of rubble are the same as those of tailings type bulkhead, which is 60% and 30% respectively.

Armor stone is also specified to be approximately 2.0 m thick and 800 ~ 1,000 kg in weight of each as in the case of tailings types.

Volume of tailings for bulkhead	24,000,000 m^3
Volume of rubble	364,500 m^3
Volume of cover stone	1,463,000 m^3

(6) Plan of water passage

a. In-flowing rivers

In the vicinity of Rabon, there are 13 rivers draining to the Lingayen Bay, including large and small ones. These rivers are shown in Fig. 10-12.

Fig. 10-9 Section of Embankment by Tailings

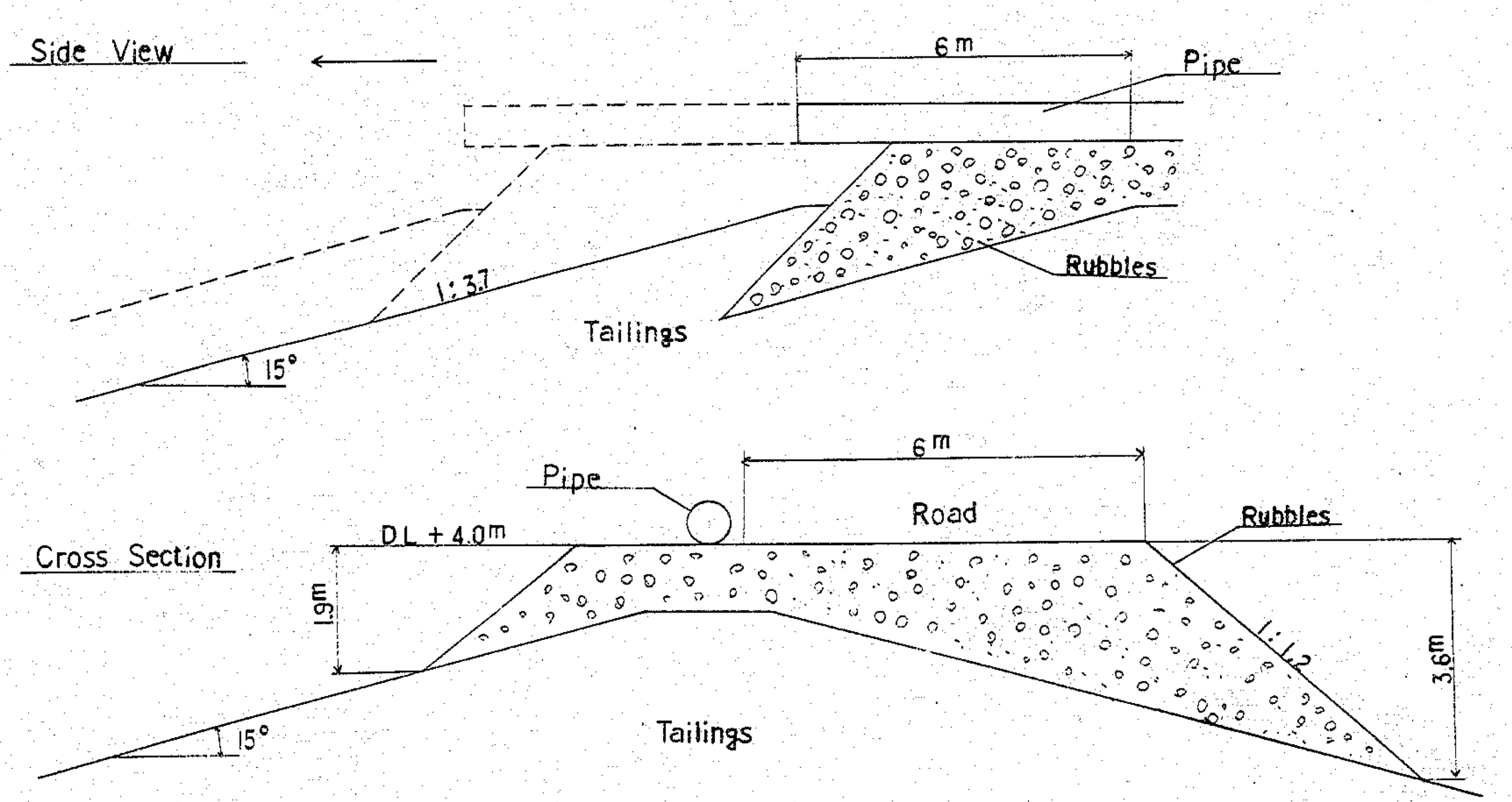


Fig. 10-10 Cross Section

Tailings Type

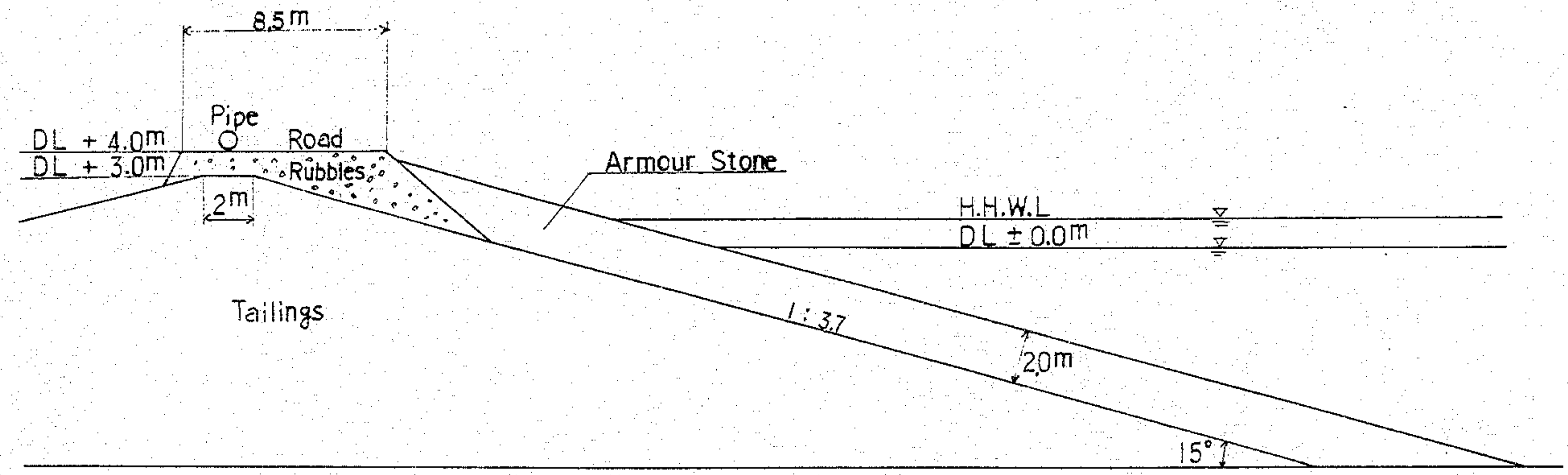
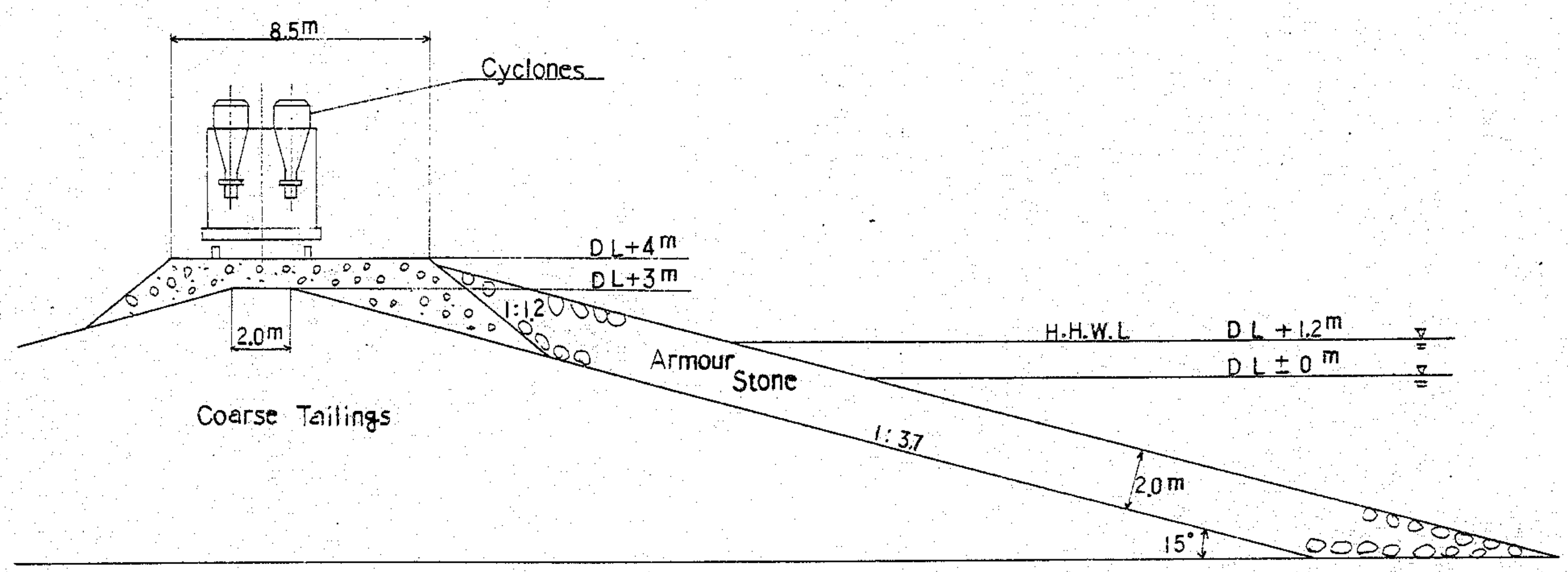


Fig. 10-11 Cross Section



They all have their water source in the coastal mountain range running in parallel with the seashore line. Therefore, their water collecting area is narrow (40 km^2, within the range of No. 1 ~ No. 8) and even during rainy season the water flow volume are not considered large.

On the assumption that the under-girder cross section area of the bridge crossing over each river indicated in Fig. 10-12 (smaller cross section is taken out of those of road and railroad bridges) is equal to the maximum flow rate, the total of these cross section areas is specified to be the cross section area of the water passage.

b. Plan of water passage

(a) Route of water passage

The water passage is situated between the reclamation land and the shore line. Water flow towards the north or the south along the reclaimed land, and in its course, the shortest route to the open sea should be selected. The construction of water passage will be made just prior to the completion of the reclamation.

(b) Structure of water passage

The water passage is placed in parallel with the shore line and its bulkhead is constructed on the seaside only. Its structure will be made of wooden bulkhead which has low construction cost. The cross section of wooden bulkhead is shown in Fig. 10-13.

(c) Quantities of wooden bulkhead required

Table 10-4 Quantities of Timber Members

SPEC. / Plan	Water passage length	Width of water passage	Timber pile		Timber sheet pile 24x30x360	Sub-timber sheet pile 12x9x360	Wire #8 x 6
			Main pile 120x4500	Anchor pile 120x2700			
B	1,200 m	20 m	2,000	2,000	3,600 m^2	360 m^2	6 x 2,000 m
D	400 m	20 m	670	670	200 m^2	120 m^2	6 x 670 m

(7) Study of scour, suck-out

According to its type, the bulkhead of the reclaimed land may be vulnerable to the phenomena of scour and suck-out. These phenomena vary with ground configuration, the nature of seabed soil, and the flow-rate of sea water. Accordingly, it is not easy to define these factors quantitatively without actual measures at the construction site. In this study, a formula to seek the scour quantity is used for estimation. In case the current flow rate is 0.5 kt and wave height $H_{1/3}$ = 2.7 m in Lingayen Bay, the obtained data is on the seabed with a water depth of 15 m soil and the tailings below 44 μ in particle size can be moved (See Appendix A-10-2-9).

The above-mentioned data are those under severe sea conditions. Under ordinary conditions, the particle size possible to move is probably smaller than the above mentioned size. At an area with less water depth, matters smaller than 44 μ are probably subject to the moving force of waves since the seabed receive more intensely the influence of the waves.

When tailings are used as bulkhead material, 20% constitute particles of less than 44 μ. For this reason, some countermeasure has to be taken to prevent occurrence of scour phenomenon. The use of asphalt, matless, block or the like are conceivable. In this study, application of rubble is taken as the means.

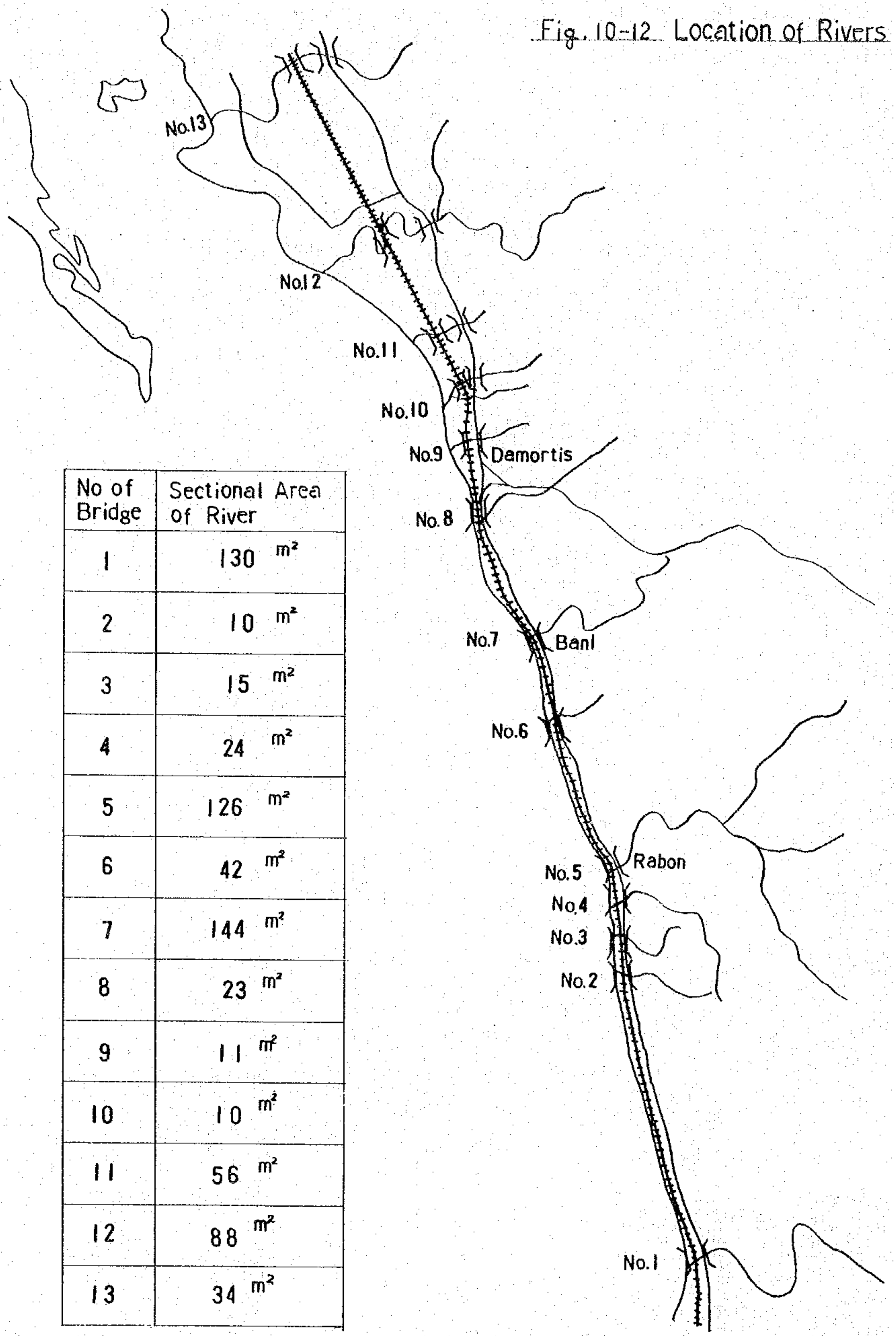
In the case of armor facing, there are openings produced through which tailings particles can be sucked out by the force of waves. Once the openings are clogged with tailings, the quantity sucked out will become smaller to negligible degree.

(8) Study of consolidation settlement

The tailings discarded in the reclamation land are subject to consolidation settlement because of their own weight. For estimation of consolidation settlement, the general practice is to make consolidation test by using some quantity of sampled tailings to get applicable basic data.

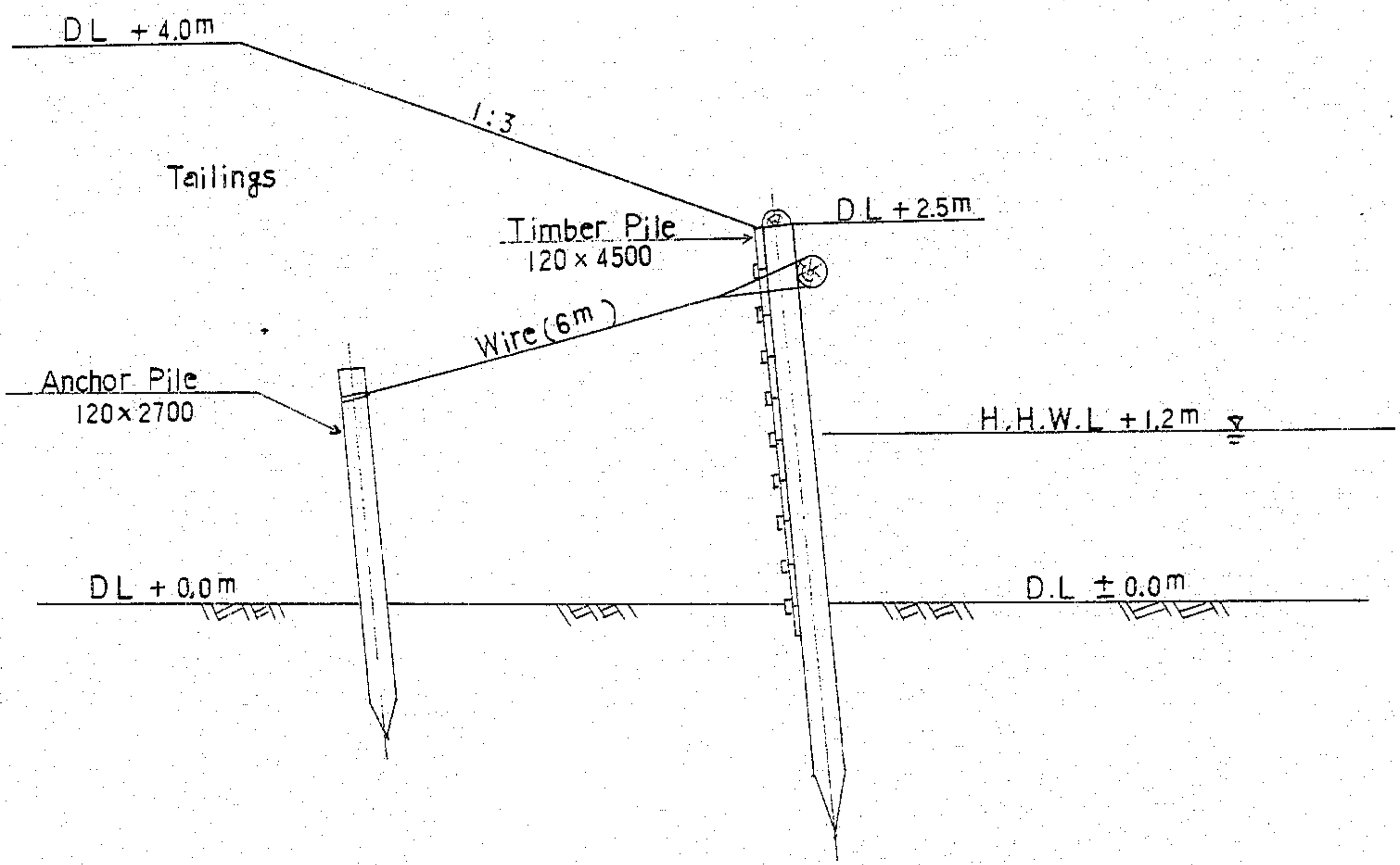
Since it is unable for us to make such consolidation test here, calculation is made on the assumption that bulk density γt = 1.4 (specific gravity of slurry) and compression index C_c = 0.30. As a result, it is

Fig. 10-12 Location of Rivers



No of Bridge	Sectional Area of River
1	130 m^2
2	10 m^2
3	15 m^2
4	24 m^2
5	126 m^2
6	42 m^2
7	144 m^2
8	23 m^2
9	11 m^2
10	10 m^2
11	56 m^2
12	88 m^2
13	34 m^2

Fig. 10-13 Cross Section of Timber Wall



estimated that the settlement of the tailings is 2.46 m to a layer thickness of 22 m and 1.12 m to 12 m. These settlement ratios nearly correspond to 10 to 11% of the thickness of tailings layer. As regards to the time length of consolidation, it will take 4.6 years to reach 90% consolidation point to 22 m layer thickness and 1.4 years with 12 m layer thickness.

In actual reclamation, the thickness of tailings layer gradually increases over a period of 20 years. Therefore, this period of 20 years has to be taken into consideration in estimating the time of consolidation (See Appendix A-10-2-10).

10.3 CONSTRUCTION PLAN

10.3.1 Preconditions of Work Plan

This Chapter describes the construction plan regarding the four types of bulkhead studied in the preceding Chapter and the reclamation work plan (piping construction) to be followed after completion of the bulkhead construction. Of the four bulkhead types, those of rubbles and corrugated cells are assumed to be completed prior to the start of tailings flow transportation and the scheduled work period is 3 years.

As to the two bulkhead types using tailings, the scheduled work period is 29 months and 42 months respectively.

In determining the work method to adopt, consideration has to be given so as to meet the present state of construction technology in the Philippines and the state of affairs in the nation. The construction plan should be compiled on the condition that the materials and machinery to be used for the construction shall be acquired locally. However, use of some import materials and introduction of other construction machinery (special work vessel) may be inevitable.

The work plan will be drawn up under the following conditions:

i) Number of work days : 25 days/month (throughout the year)

ii) Work hours : On land 12 hrs/day
Offshore 10 hrs/day

10.3.2 Work Plan for Construction of Rubble Type Bulkhead

(1) Study of work method

The construction work of rubble type bulkhead is classified into offshore work and on-land work.

The on-land work generally practised is to carry rubble by dump truck on the two routes (the both edges of reclamation land) and cast the rubble to build the bulkhead then level the casted rubble with bulldozer. The construction work is continued by repeating the process to go ahead in right angle to the shore line.

For offshore work, the following three types are conceived practical.

i) Sand carrier with grab (gut ship)

ii) Bottom openable barge

iii) Pontoon + bulldozer

iii) is a method that loads rubbles on pontoon from which the rubbles is cast in the place by bulldozer.

The features of these methods are summed up in Table 10-5. From Table 10-5, it is understood that for a large scale rubble casting work is generally made by using bottom-openable barge.

For this project, the use of bottom-openable barge is considered preferable in view of its large scale and the work period could be shortened. After the level of rubble bulkhead rises up to DL-5 m, the work of rubble casting and sideslope adjustment will be made by the use of gut ship. On the sections where rubble casting is finished, the sideslope face is shaped and subsequently covered with armor stone by diver workers. The armor stones are cast in the place where rubbles is casted.

(2) Development of quarry

For the construction of rubble bulkhead, a volume of 4,679,000 m^3 is consumed. Therefore, it is an essential task to have a quarry near the site to ensure stable rubble supply. At present, there is no source in the vicinity. So, the plan is to develop a quarry within 15 km from the reclamation site and the shipping lot.

Table 10-5 Comparison of Rubbles Transportation and Casting Methods

Kinds	Loading capacity	Self-propelled or nonself-propelled	Casting method	Advantages	Disadvantages
o Sand carrier with grab (gut ship)	100t ~ 400t	Self propelled	Cast with bucket	. Easy to set the boat to the place because of the self-propelling ability. . Adjustment of side-slope gradient can be made.	. Takes much time to make rubbles casting. . Unsuitable to employ for large scale construction
o Bottom-openable barge (self-propelled)	100^{m^3} ~$2,500^{m^3}$	Self propelled	Cast through opening in bottom	. It is possible to make large volume transportation. . Easy to set the boat at the place.	. Adjustment of side-slope cannot be made. . The number of vessel available is comparatively small.
o Bottom-openable barge (nonself-propelled)	100^{m^3} ~$6,000^{m^3}$	Nonself propelled	Same as above	. It is possible to make large volume transportation. . With boats available in plenty, it is suitable for large scale construction.	. Unable to make side-slope adjustment.
o Pontoon + Bulldozer	100^{t} ~ 400^{t}	Nonself propelled	Push out rubbles by bulldozer	. Combination use is easy and readily applicable to other construction work.	. Hard to set its position. . Low work efficiency. . Sideslope adjustment is impossible.

It is possible to develop a quarry that can satisfy the volume requirement and the condition of transportation distance within 15 km. (somewhere near Camp 1 will be pointed). It is prferable to develop the quarry as a Government sponsored N.P.A. Project work as applied to construction of Navotas Port.

(3) Loading and transportation work

Wheel loader will be used for rubble loading at the quarry. The designed length of the transportation route from the quarry to the reclamation site and the shipping lot is 15 km. This route needs a width larger than 7.0 m to permit passage of dump trucks. It is most desirable to prepare an exclusive road for the transportation. However, the existence of the national road could be used for access to the reclamation area which has a sufficient width and not so dense in traffic. Therefore, use of this national road will be planned as far as it is permissible.

(4) Shipping facilities

There is San Fernando Port in the vicinity of the reclamation area but this Port is 55 km away from the area. Except for the quarry and rubble stockyard exsiting near the port, we cannot find any specific merits in using this port. As there are no other big ports around San Fernando, we will plan to install a temporary pier near the land where rubble is carried by bottom-openable barge or gut boat.

As for the loading method, a slope will be provided to the temporary pier (Fig. 10-14) through which to transship rubble for the dump truck into the carrier boat without preparing stockyard near the temporary pier. As shelter harbor for carrier boats, San Fernando or Sual will be proposed in the plan.

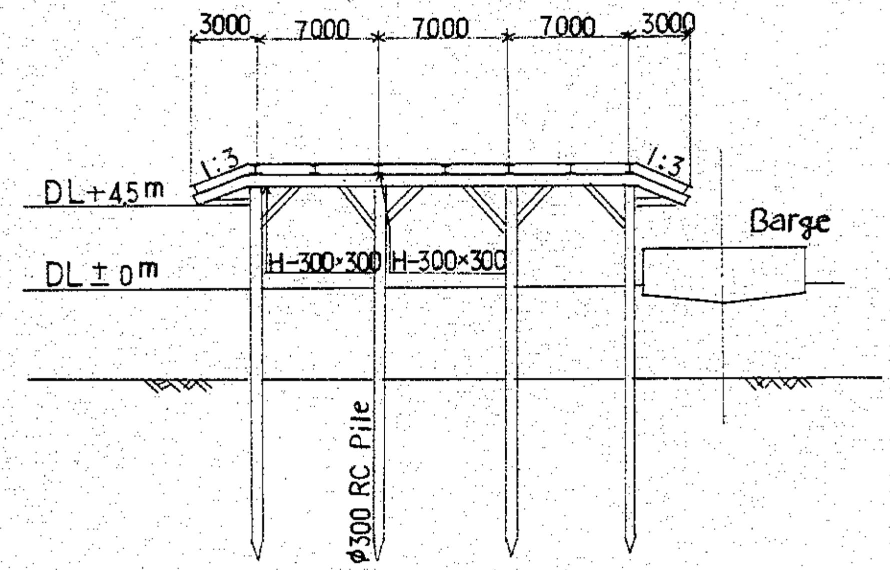
(5) Explanation of work method

The work method to be employed is shown in Fig. 10-15 Flow Sheet. The proportion of handled rubble quantities allocated to offshore work and on-land work will be determined according to the scale of work boats to be used.

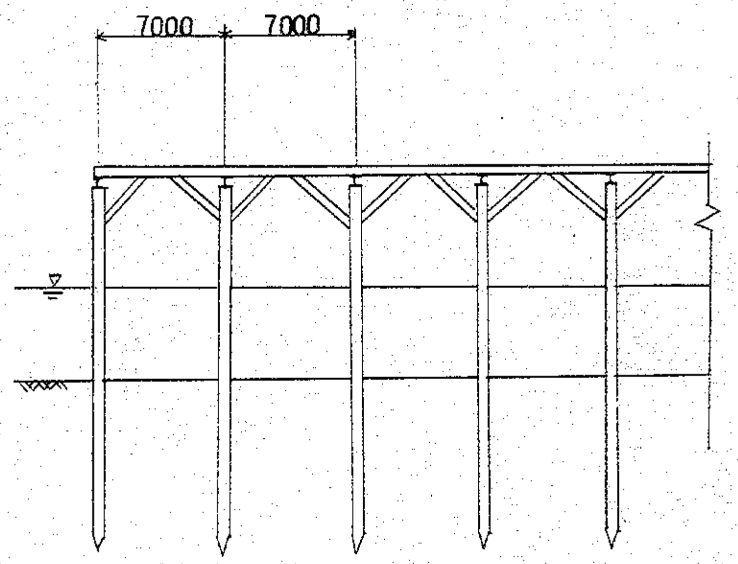
To mention, rubble materials will be supplied to the temporary pier to keep pace with the work cycle of the boats employed. The surplus rubble will be used for on-land work performance.

Fig. 10-14 Pier

Cross Section



Side View



Profile

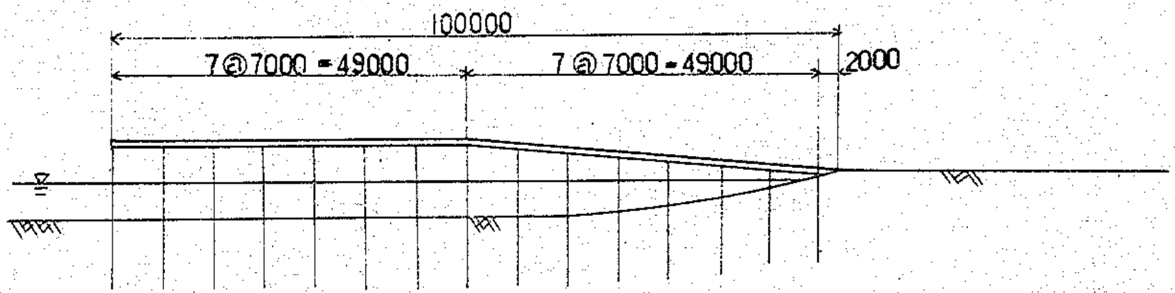


Fig. 10-15 Working Flow of Rubbles Bulkhead