The on-going Apia Port Development Project commenced in March, 1989 under a Japanese grant aid assistance and consists of the following major components.

1	Repair of the main wharf	185 m
2	Expansion of the concrete deck of the main wharf	61.5 m x 18.0 m
3	Expansion and heavy duty pavement of the container yard	2,000 m^2
4	Ferry terminal mooring facilities	
	- wharf	20 m
	- mooring dolphin	50 m
5	Ferry terminal building	522 m^2
6	Breakwater with a marking light	100 m
7	New tug boat	1 (1,600 PS)
8	Port management equipment	
	- 3 ton truck	1 (repair work and transportation)
	- pick-up truck	1 (patrol and transportation)
	- 4 wheel drive vehicle	1 (supervision of port operation)
	- computer system	1 set (port statistics & accounting)

2.3.4 Road Improvement Plan

The 5 year plan of road improvement planned by the PWD has been amended in consideration of urgent restoration works required for the damage caused by the cyclone "Ofa". It is estimated that 30,000 m^3 and 70,000 m^3 of stone materials will be required for the restoration works for Upolu and Savaii Islands respectively. While, about 22,000 m^3 of stone materials is required for regular maintenance and improvement works of road. The following points have been taken into consideration in amending the original plan.

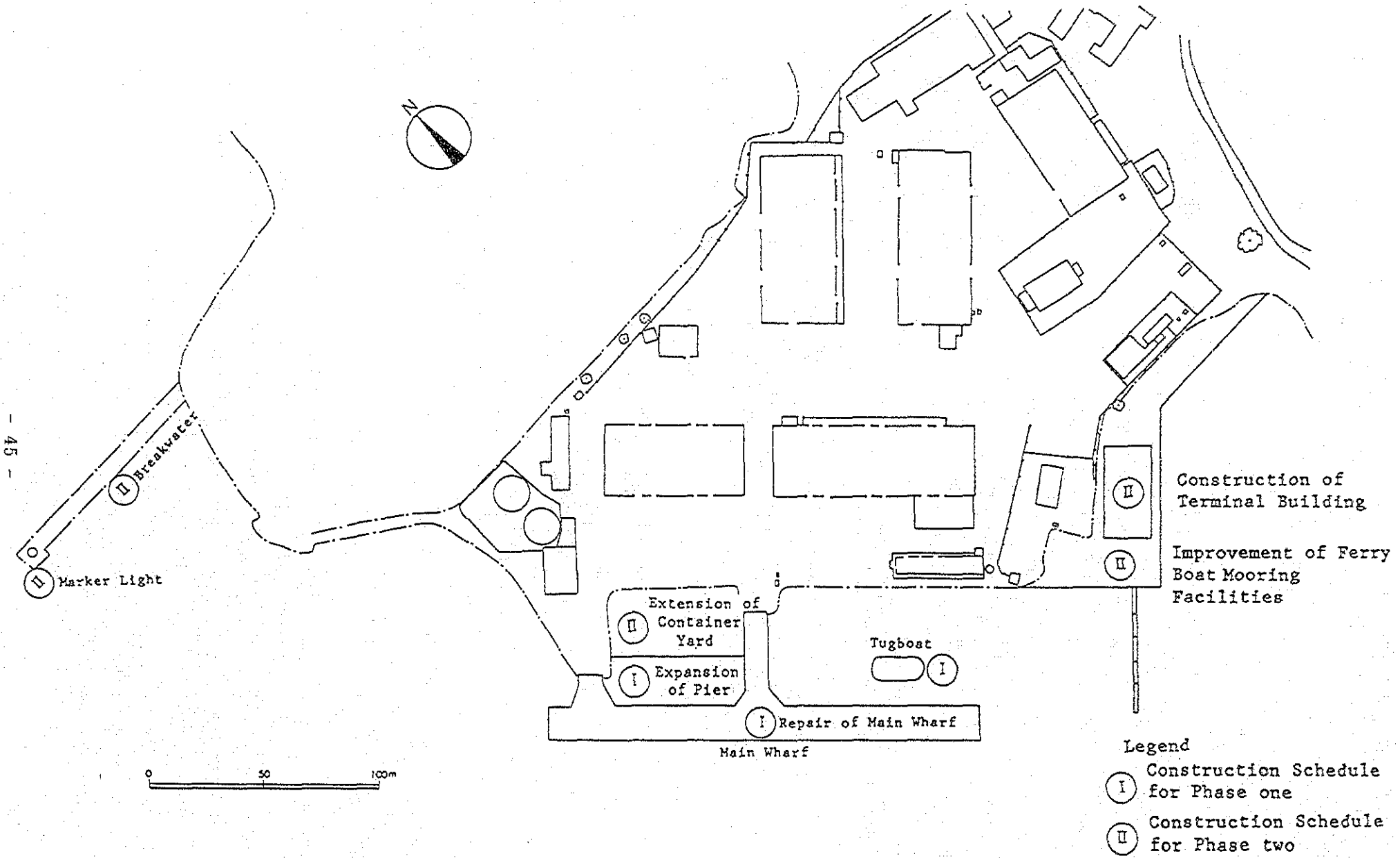


Fig. 2-16 Apia Port Development Project

1 The new quarry will become operational in July, 1991.

2 Priority has been given to Upolu Island in view of the larger population of 120,000, i.e. three times that of Savaii Island, and the higher urgency of restoring the road network there.

3 The production plan of stone materials for the road development work, etc. has to be coordinated with the production capacity of quarry, project priority and budgetary plan.

4 Construction of Lemafa/Richardson Road (28 km, Route No. 1 in Fig. 2-17) has already been started under the financial assistance of the ADB. Since a quarry plant (production capacity of 150 t/h) producing stone materials for the work is specified to be provided by the contractor, the demand of stone materials for this road is not included in the demand of stone materials in the present project.

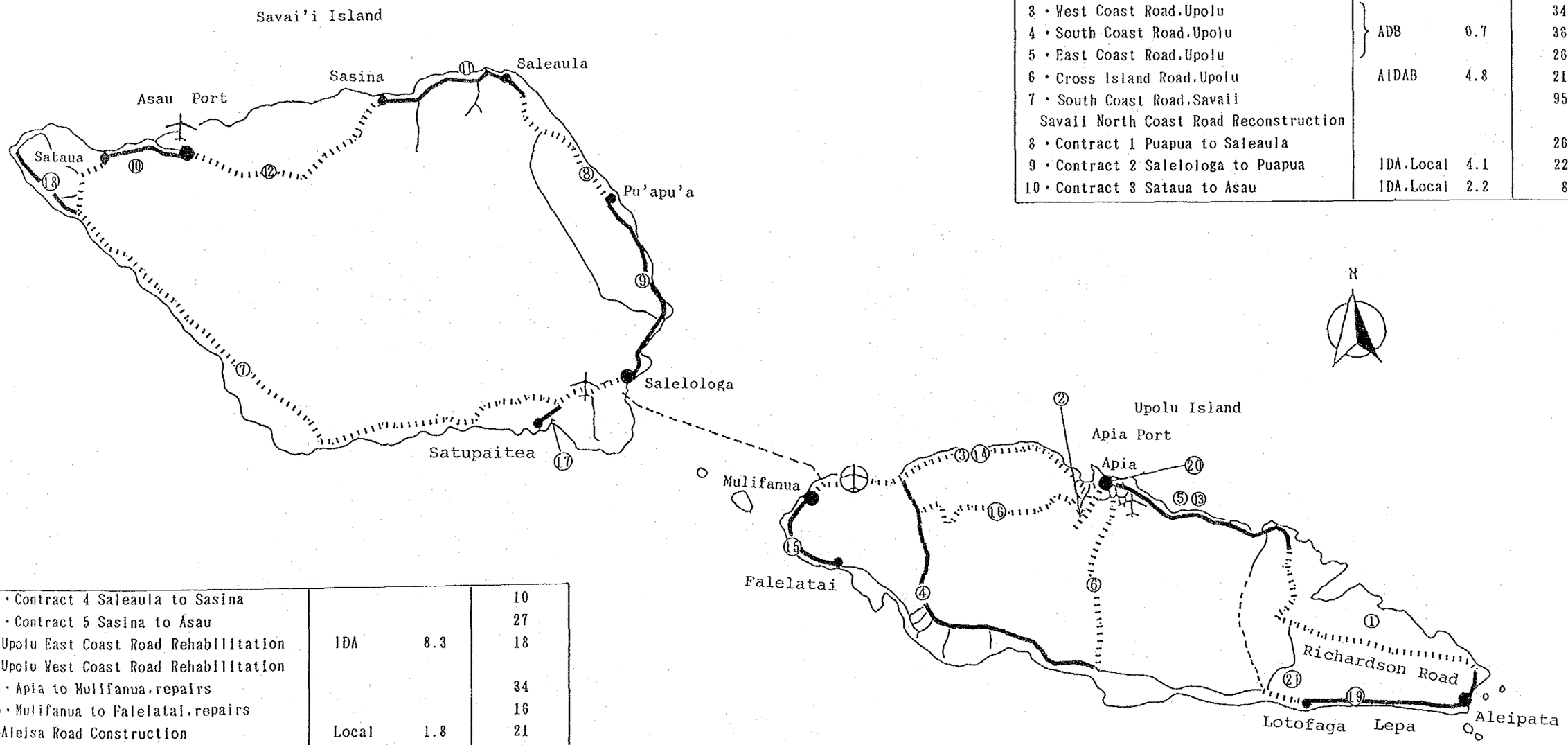
The medium-term road improvement plan following the above revision and the locations of road improvement projects are shown in Table 2-6 and Fig. 2-17 respectively.

The PWD is currently implementing the road improvement work described in 4 above and this work is outlined as follows.

- Construction Cost - 9,257,000 WS$
- Construction period - late January, 1990 - late October, 1991
- Total road length for improvement - 28.36 km
- Required volume of crushed stone - 75,900 m^3
- Crushing plant capacity - 150 t/h

Assuming that the number of working months of the quarry plant is 15 out of 20.5 months, required monthly operation hours of the quarry is calculated as 141 hours and the quarry plant plan for the project is deemed appropriate.

Western Samoa



Projects	FINANCE	(Mil.US$) Project Cost	Length km
1 Lemafa/Richardson Road	ADB	5.4	28
2 Vaimoso Bridge Approaches	UNDP	0.5	
Rural Highway Resealing Project			
3 ・West Coast Road,Upolu			34
4 ・South Coast Road,Upolu	ADB	0.7	36
5 ・East Coast Road,Upolu			26
6 ・Cross Island Road,Upolu	AIDAB	4.8	21
7 ・South Coast Road,Savaii			95
Savaii North Coast Road Reconstruction			
8 ・Contract 1 Puapua to Saleaula			26
9 ・Contract 2 Salelologa to Puapua	IDA,Local	4.1	22
10・Contract 3 Sataua to Asau	IDA,Local	2.2	8
11・Contract 4 Saleaula to Sasina			10
12・Contract 5 Sasina to Asau			27
13Upolu East Coast Road Rehabilitation	IDA	8.3	18
Upolu West Coast Road Rehabilitation			
14・Apia to Mulifanua,repairs			34
15・Mulifanua to Falelatai,repairs			16
16Aleisa Road Construction	Local	1.8	21
17Satupaitea Road Construction			3
18Falealupo Road Construction			10
19Eastern Upolu Roads Construction (Lotofaga-Lepa-Aleipata)			23
20Apia Road Rehabilitation			
21Upolu South Coast Road Rehabilitation	(Contract Suspended)		21
PWD Maintenance			
22・Recurrent	AIDAB	3.7	
23・Periodic Resealing	IDA		

Fig. 2-17 Road Improvement Plan

Table 2-6 Demand of Crushed Stone,Medium Term Road Improvement Plan

Projects	Length (km)	Y E A R						
		1990	1991	1992	1993	1994	1995	1996
1.Lemafa /Richardson Road	28	18.960	53.000					
2.Valmoso Bridge Approaches Rural Highway Resealing Project	1	40						
3. ・West Coast Road,Upolu	34		2.600					
4. ・South Coast Road,Upolu	36			3.240				
5. ・East Coast Road,Upolu	26			480				
6. ・Cross Island Road,Upolu	21				1.680			
7. ・South Coast Road,Savaii Savaii North Coast Road Reconstruction	95						1.560	4.800
8. ・Contract 1 Puapua to Saleaula	26			9.000				5.500
9. ・Contract 2 Salelologa to Saleaula	22		5.250	10.500	10.500	10.500	10.500	5.250
10. ・Contract 3 Sataua to Asau	9			3.500	3.500	3.500	3.500	3.500
11. ・Contract 4 Saleaula to Sasina	10				5.600			
12. ・Contract 5 Sasina to Asau	27						7.500	7.600
13.Upolu East Coast Road Rehabilitation Upolu West Coast Road Rehabilitation	19		7.500	7.500	7.500	7.500		
14. ・Apia to Mulifanua,repairs	34			4.100			4.100	
15. ・Mulifanua to Falelatai,repairs	16					3.800		
16.Aleisa Road Construction	21				7.000	7.000		
17.Satupaitea Road Construction	3					—		
18.Falealupo Road Construction	10						—	
19.Eastern Upolu Roads Construction (Lotofaga-Lepa-Aleipata)	23					1.000	3.400	3.400
20.Apia Road Rehabilitation	10				1.440	2.880	2.880	2.880
21.Upolu South Coast Road Rehabilitation PWD Maintenance					—			
22. ・Recurrent	120		480	960	960	960	960	960
23. ・Periodic Resealing							1.200	1.800
Annual Road Improvement Plan	541		8.330	17.780	16.680	15.640	21.600	26.940
Restoration Works	50		7.500	21.500	21.500	21.500	14.000	8.750
T o t a l	591		15.830	39.280	38.180	37.140	35.600	35.690

2.4 Background and Contents of the Request

The total amount of damages caused by the cyclone "Ofa" was estimated at 120 million US$. The Government of Western Samoa declared a state of emergency on 4th February 1990 immediately after the cyclone and has organized the National Disaster Council which requested assistances to Foreign Governments and international assistance agencies. Donors are assisting Western Samoa in their traditional areas of emphasis, for example, port by Japan, road by Australia and agriculture and education by New Zealand.

The Government of Japan, in response to the emergent request of assistance, made a donation of 0.1 million US$ together with generator, water tub, water purifier, wireless equipment, etc. followed by dispatch of a coordinator for assistance who conducted a detailed survey on the cyclone damages.

In March, 1990, the Prime Minister, the Honourable Tofilau Eti Alesana visited and requested the Government of Japan a grant aid for restoration of the damaged port facilities and provision of a quarry plant as follows.

(1) Restoration Work of Port Facilities

1 Apia Port

a. breakwater
b. causeway
c. seawall
d. dredging of mooring basin
e. wooden fender

2 Mulifanua Port

a. dredging of navigation channel
b. ferry ramp
c. -3.5 m wharf
d. seawall

3 Salelologa Port

a. dredging of navigation channel

4 Navigation Aids

a. beacons in Apia Port and buoys in the fishing port
b. entrance beacons in Mulifanua Port
c. navigation aids in Mulifanua, Salelologa and Asau Ports
d. lighthouses at Apolima, Malua Reef and Aleipata

5 Miscellaneous

a. port communication facility
b. pilot/work boats

6 *Sheds and Marine office*

(2) Crusher and Ancillary Equipment

1	Crusher	100 t/h	1
2	Generator	270 KV	1
3	Loaders (for raw rock)	2.4 m^3	2
4	Dump Trucks	12 ton	4
5	Loader (for crushed rock)	1.7 m^3	1
6	Drills	63-90 m/m	2
7	Bulldozer	35 ton	1
8	Backhoe	1 m^3	1
9	Workshop	380 m^2	1
10	Truck with crane	4 ton	1
11	Small Trucks	1 ton	2
12	Office Vehicle	4,000 cc	1

CHAPTER 3

CONTENTS OF THE PROJECT

CHAPTER 3 CONTENTS OF THE PROJECT

3.1 Objectives of the Project

Western Samoa suffered serious damages caused by the cyclone "Ofa" in February, 1990 as detailed in the previous chapter. The Government of Western Samoa made an urgent request to foreign governments and international assistance organizations for disaster restoration. Prime Minister, the Honourable Tofilau Eti Alesana visited Japan in March 1990 and requested provision of a Japanese grant aid for the restoration of port facilities and the provision of a quarry plant. The present project intends to, for achievement of an early recovery of sea and land transportation severely curtailed, work out rehabilitation plan of damaged port facilities and a provision of a quarry plant to supply stone materials required for restoration works, thereby contributing to a quick recovery of the Western Samoan economy from the damage caused by the cyclone.

3.2 Examination of the Request

3.2.1 Appropriateness of the Project

(1) Port Facilities

Contents of the request for the restoration of the port facilities damaged by the cyclone "Ofa" are basically judged to be appropriate for a grant aid project of the Government of Japan as discussed in the subsequent section, the Examination on Contents of the Request.

With regard to management of the port facilities after restoration, since there will be no increase of their scale and functions, the present management system of the Ministry of Transport is sufficient. In addition, a new management system of Port Authority is expected to be introduced in 1991 and no financial difficulties are anticipated.

The restoration of the original functions of the port facilities through the implementation of the project will have the following effects.

1 In addition to smooth implementation of the on-going project in Apia Port, cargo handling, cargo control and port management will become more efficient and safer.

2 Restoration of the normal ferry service in Mulifanua and Salelologa Ports will reduce transportation time and cost and relieve Apia Port from temporary ferry service.

3 Restoration of the navigation aids will ensure navigational safety.

(2) Quarry Plant

The contents of the request related to a crusher and ancillary equipment are considered to be appropriate for a grant aid by the Government of Japan as described in a subsequent section. All three quarry plants owned by the PWD have deteriorated and the one in Savaii Island has in fact been abandoned. Although attempts are being made to repair two plants in Upolu Island for their reoperation in a smaller scale, perfect repair is impossible due to the poor condition of the crusher and ancillary equipment which are far beyond their serviceable lives. In view of these conditions, it is reasonably assumed that the existing quarry plants can not meet a temporarily increased demand of stone materials for the restoration of the cyclone damage.

Due to insufficient production capacity of crushed stone, many construction projects are suspended, canceled or implemented in a very inefficient manner. The projects which require large volume of stone materials such as construction works of road, water supply, port, seawall, etc. are seriously affected. Introduction of the new quarry plant will contribute an early

recovery of economy by facilitating an efficient implementation of restoration works of basic infrastructure.

The production capacity of the quarry plant is planned at 100 t/h enough to meet the whole demand of crushed stone in the country. It is not desirable to develop many small quarries near construction sites for each project causing environmental disruption.

As the reserve and the physical property of rock in the Alafua quarry have already been confirmed, there are no technical problems regarding construction of a quarry plant there.

In the field of quarry management, the PWD has experience of operating quarry plants and still retains engineers and operators to run a quarry. Further, an Australian expert dispatched by the Australian Government is currently training local staff in preparation for operation of a new quarry plant and, therefore, no manpower problems are anticipated.

Based on the comprehensive examination results described above, the introduction of a new quarry plant is not expected to bring any technical or economic problems. In view of urgency and publicity of the planned restoration works, and the quarry plant, this project is recommended to be implemented under a Japanese grant aid at the earliest possible opportunity.

3.2.2 Operation and Administration Plan

(1) Port Facilities

Since there will be no increase in scale and function of the port facilities to be restored in this project, the present organization and budget of the MOT need no change to run the port after restoration works.

(2) Road Facilities

1) Improvement and Maintenance of Road

All the roads in Western Samoa are under control of the Civil Department of the PWD the major works of which are as follow.

i) Planning of road development/improvement projects

ii) Design, cost estimate, tendering and construction supervision

iii) Inspection, maintenance and repair works

iv) Operation and administration of quarries

The PWD consists of 7 departments with 236 staffs and the Civil Department consists of the construction, design and quarry sections with 83 staffs. Budget for road improvement increased from 0.8 million US$ in 1985 to 1.9 million US$ in 1989.

2) Quarry

The existing quarries are operated under the direction of the Chief Civil Engineer of the PWD. A stockyard and an administration office, etc. have already been prepared and construction of blasting benches is currently in progress. The Alafua quarry, therefore, is ready to commence operation as soon as the new plant is constructed. The organization of quarry consists of an overseer, two foremen and 15 workers as shown in Fig. 2-8 and an annual budget is about 0.3 million US$. Capacity of the new crushing plant is larger than that of the existing one and the total number of staffs is planned to increase to 31 under a new institution of self financing corporation controlled by the PWD. Annual operating cost is estimated at about 1.7 million US$ and can be met by earning of sale of crushed rock.

While intensive restoration works are urgently required, excessive concentration of the work in a period of one or two years may lead to imbalance of supply and demand, resulting in adverse effects on the economy of Western Samoa in terms of procurement of construction materials, equipment and manpower and a financial capability of the Government of Western Samoa. In consideration of these conditions, the present project intends to spread the road restoration works over the period between 1991 and 1996. During this period, routine maintenance and new road construction works are curtailed so that the overall volume of the road construction/improvement works or the demand of crushed stone will not be drastically changed before and after the restoration work. The quarry plant with a production capacity of 100 t/h to be constructed under the project is considered adequate in its capacity to meet the demand even after completion of the various restoration works.

3.2.3 Relevant Projects

(1) Port Improvement

The following two projects are presently in progress in Apia Port.

1) Apia Port Development Project (Phase II)
   Financial source : Japanese grant aid
   Grant Amount : 6.09 million US$

2) Apia Port Container Park Development Project
   Financial source : ADB
   Loan Amount : 670,000 US$

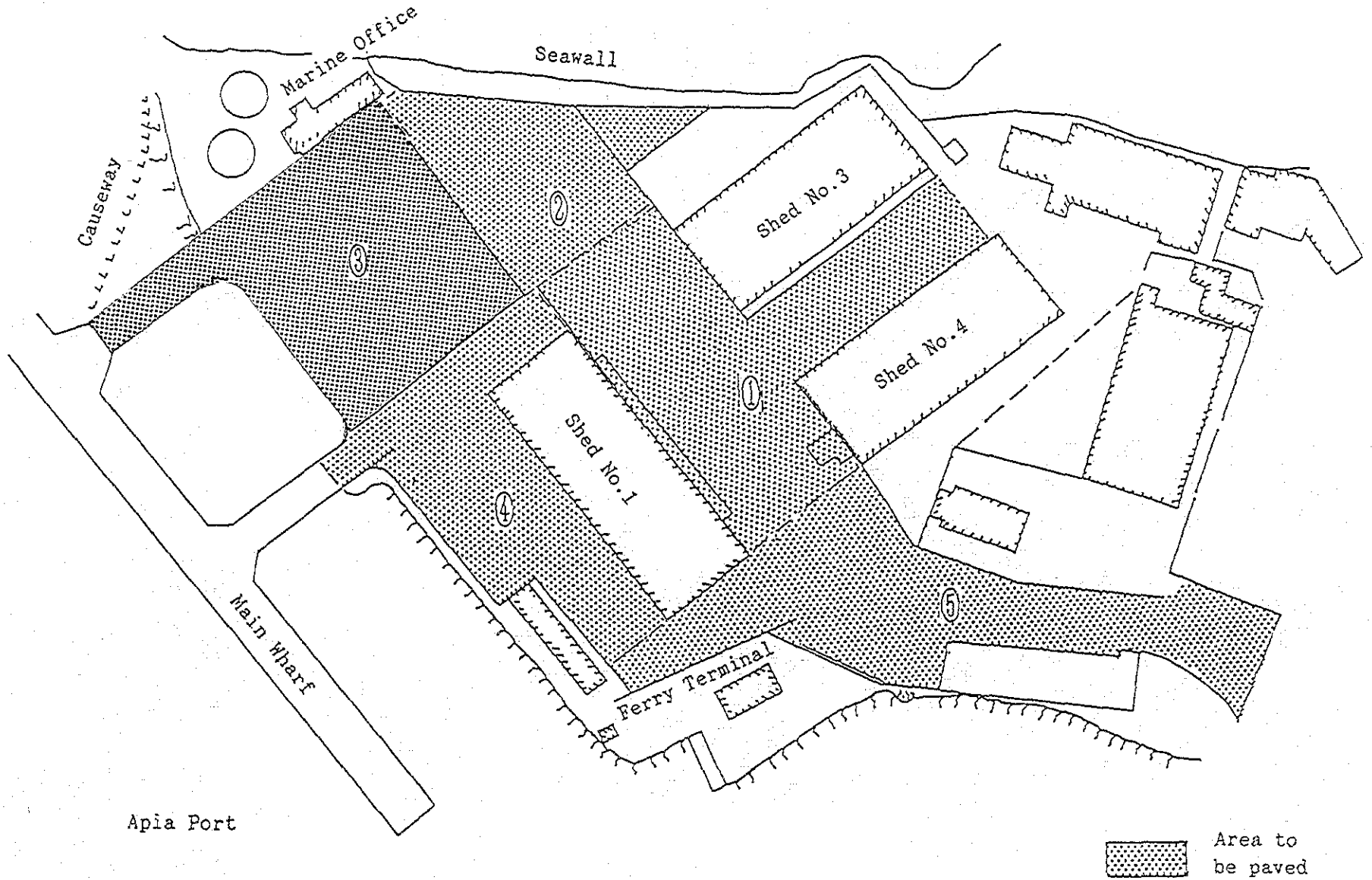


Fig. 3-1 Pavement Project of ADB

The Government of Western Samoa intends to restore all the port facilities damaged by the cyclone "Ofa", with a grant aid assistance of the Government of Japan and does not plan to seek assistance from any other country or organization.

The extent of the damage to port facilities which are being developed under the above 2 projects is as follows.

1) The reclamation work for the expansion of the container yard under the Japanese grant aid project and the paving work under the ADB project have been delayed as the causeway has been extensively damaged.

2) The paving work under the ADB project for the section between the port office and the shed No. 3 at the back of the seawall (as shown in Fig. 3-1) has been delayed due to collapse of the seawall and loss of the back-fill material.

The Government of Western Samoa has requested the Government of Japan to include the restoration of the causeway and the seawall as urgent items in the planned grant aid assistance.

(2) Road Improvement

The Government of Western Samoa is currently implementing the following road improvement projects with foreign assistance.

1 Upolu Island East Coast Road Improvement Work
(Lemafa/Richardson Road: 28km)

Financial source : ADB
Loan Amount : 4.1 million US$

2 Upolu Island Trunk Road Paving/Repair Work

Financial source : Australian International Development Assistance Bureau (AIDAB)
Loan Amount : 5.1 million US$

3 PWD Workshop Expansion Project

Financial source : AIDAB
Loan Amount : 7.5 million US$

As described in 2.3.2 (2), there is the other plan financed by the IDA and the Government of Western Samoa to restore the roads damaged by the cyclone "Ofa".

According to the Medium-Term Road Improvement Plan which has been revised taking the urgent restoration works into account (Table 2-6), the Government of Western Samoa plans production and supply crushed stone (except for the ongoing Lemafa/Richardson Road improvement work financed by the ADB) as follows.

1 As development of a quarry near the construction site for each road project would result in environmental destruction, the new quarry plant to be introduced by the PWD will meet most of the domestic demand for crushed stone. Production of crushed stone by a large quarry plant will facilitate efficient plant management and supply of high quality and low price stone material.

2 The Alafua quarry has been selected as a construction site for the new quarry plant due to the following reasons.

- The rock of hard basalt is adequate for road and concreting works.
- The reserve is expected to meet the demand for more than 50 years.
- The site is only 15 minutes from Apia downtown and this will allow for economical marine transportation of crushed stone to Savaii Island.

3 Marine transportation involving a large barge and tug boat will supply crushed stone to Savaii Island through berthing facilities in Asau, Fagamalo, Faletagaloa, Faga and Salelologa.

3.2.4 Examination of the Request of Port Facilities

All the requested port facilities are examined here in terms of their importance, urgency and effectiveness in order to assess the necessity of their restoration.

1) Apia Port

1 Causeway (90 m)

The causeway plays an important pole as a connecting road between the main wharf and the container yard. As the Apia Port Development Project under the grant aid assistance of the Government of Japan and the Container Yard Paving Project financed by the ADB loan include some work at the causeway section which was washed away by the cyclone, the urgent restoration of the causeway is essential for the implementation of these two projects. With access to the main wharf secured by the restoration of the causeway, cargo handling operation is expected to become more efficient and safer.

2 Seawall (200 m)

The seawall is an important structure to protect the oil tanks, sheds, marine office building and container yard, etc. from damage by waves. The collapse of the seawall has resulted in erosion of land and destruction of buildings.

While the concrete fence enclosing the tank yard has been rebuilt by retreating it inwards, the fence between the marine office and the shed No. 3 cannot be repaired without restoration of the seawall, resulting in a security problem of pilferage.

The urgent restoration of the seawall is required to secure safety of the onshore facilities and security in the port area.

Restoration of the seawall is examined together with restoration plan for the breakwater. The seawall shall be urgently restored to the previous section in such a manner that it not disturb the view to the open sea from the port area.

3 Breakwater (60 m)

The breakwater plays important roles of sheltering the main wharf and the causeway from the waves and also providing land access to the 100 ton bollard located at the far end of the breakwater. The loss of the breakwater due to the cyclone "Ofa" has made the causeway and the main wharf to be affected by direct wave action. Restoration of the breakwater will not only improve safety of port operation but also improve efficiency of cargo handling operation.

As described in detail in Chapter 4, two alternative alignments for the new breakwater are considered. The alternative plan is to connect the corner of the Shed No. 3 and the new breakwater under the Apia Port Development Project, while the other alignment is on the original line of the lost breakwater. A comprehensive study of these two plans, taking the rehabilitation of the seawall into consideration, found that the protective function and construction cost would be almost the same for both plans. Since the Government of Western Samoa express preference on the alternative plan from the viewpoint of a long term development plan of the port, the alternative layout of the new breakwater shall be adopted.

4 Mooring Basin for Small Boats (6,000 m^2)

The water area behind the main wharf provides an important mooring basin for such small boats as tug boats, pilot boat, etc. The waves caused by the cyclone moved sand and rubbles into this basin. Moreover,

containers and other objects fell into and shallowed the area. It was informed that navigation of the "Tafola", the tug boat with the deepest draft, became difficult. The field study found that the depth of the basin became shallower by about 1 m in the area deeper than 5 m. As the full draft of the Tafola is only 2.8 m, however, the basin will not be causing any problems in maneuvering and mooring the Tafola. Therefore the dredging of the basin has been omitted from the project items in view of its low priority and effectiveness.

5 Pilot/Work Boats (2 Nos.)

These identical 5 m long aluminum pilot and work boats serve various purposes and in transporting pilots to calling ships. The deck and steering house of both boats were damaged by the cyclone in addition to damage to an outboard engine, causing difficulties in pilotage and mooring operation. The urgent repair of these boats is crucial to secure smooth port operation. Both boats and the outboard engine can be made operational if the damaged parts are replaced or repaired.

6 Navigation Aids (2 Nos.)

The light tower in Apia Port and the light buoy in Apia Fishing Port are important navigation aids which indicate the locations of shallow reefs to incoming and outgoing ships. The collapse of light tower and the loss of lantern of the light buoy result in difficulty of navigation. The light tower and light buoy have to be restored as soon as possible to ensure safe navigation. With regard to the light tower in Apia Port, since a new light tower will be installed at the far end of the new breakwater, a simple light post shall be erected in the previous location.

7 Marine Office (280 m^2)

The marine office is an important facility accommodating about 20 full-time employees of the Port department. They are engaged in administering the arrival and departure of ships, operation of tug boats and other activities. As the building is located near the collapsed revetment, the damage is serious and beyond repair. At present, vinyl sheeting is being used as a temporary replacement of the lost wall and roof and a temporary toilet has been constructed.

It is obvious that efficient port management can not be conducted under the present poor conditions and, therefore, it is imperative to demolish the existing building and to construct a new office building. The Ministry of Transport intend that the new marine office building be constructed near the main wharf in front of the Shed No. 1 for efficient port management.

8 Sheds No. 1 and No. 3 (No. 1: 3,645 m^2, No. 3: 2,542 m^2)

These two sheds are owned by the Ministry of Transport and they are currently leased to private companies. The damage to the sheds is serious and vinyl sheeting is being used to cover cargoes stored in the sheds. Damages to the cargoes by rain is a serious problem together with security of the cargoes due to the broken doors and walls. The urgent repairs to the damaged sections are required to reduce the damage to cargoes and to improve security.

9 Wooden Fender (90 m)

The wooden fender is an important facility installed at the back of the southern half of the main wharf for mooring such small boats as tug boats, pilot boat, etc. Damage caused by the cyclone, including breakage of

wooden piles, however, now makes safe mooring operation difficult.

The urgent repair of the damaged wooden piles and beams, etc. is necessary to secure safe mooring of tug boats and other small boats.

2) Mulifanua Port

1 Navigation Channel (500m long, 50m wide)

The navigation channel in Mulifanua Port is a very important facility connecting Upolu Island and Savaii Island. The strong waves caused siltation along the channel of about 500 m and the turning basin and made ferry operation impossible due to shallow water. At present, the Lady Samoa II is operating between Apia Port and Salelologa Port and the other ferry boat with a shallow draft is operating between Mulifanua Port and Salelologa Port at high tide. Ferry users are being greatly inconvenienced due to an irregular operation of the ferry service and the higher transportation cost resulting from the longer sailing distances.

The urgent dredging of the navigation channel and the turning basin is necessary to reduce both transportation time and cost by reinstating the normal ferry service.

2 Ferry Ramp (24 m)

The ferry ramp is an important facility allowing ferry boats to berth for cargo handling as well as for boarding and unboarding of passengers.

The grounding to the ramp of the Lady Samoa II damaged the upper portion of the ramp and a fender. In addition, the back-filling material was washed away by the waves. Although a ferry boat with a shallow draft is

being used to provide a temporary ferry service, the ramp is in a dangerous condition that the cavity under the concrete apron makes the ramp unstable against such heavy loads as vehicles with full load. The urgent implementation of the rehabilitation work is, therefore, required. In addition, emergency repair work is required to fill the cavity under the apron as a safety measure before the commencement of the above rehabilitation work.

3 -3.5 m Wharf (40 m)

While the ferry ramp is used mainly for passenger transportation, the -3.5 m wharf used to be used for cargo transportation by small local boats. The wharf was directly attacked by the cyclone waves. All the concrete piles were broken and the concrete apron was destroyed together with the beams, completely losing its function.

At present, the wharf is no longer in full use for cargo transportation, though it can be occasionally used for temporary berthing by fishing boats and small ferry boats during the rehabilitation work of the ferry ramp, the earlier repair of the apron is necessary. The use of the repaired wharf by such heavy vehicles as trucks, however, should be restricted.

4 Seawalls (200 m)

The south and north seawalls are important to protect the roads and buildings from waves. Both seawalls in Mulifanua Port were damaged by waves. Damage to the north seawall which protects the access road to the -3.5 m wharf includes the seaward one lane of the road. The urgent rehabilitation of the damaged sections is required to ensure safety of such on-shore facilities as roads and buildings.

5 Navigation Aids (2 Light Beacons and 11 Marking Posts)

The light beacons and marking posts are important navigation aids to indicate the direction and boundaries of the navigation channel for ferry operation. All the marking posts and front light beacon are washed away and rubber ball floats are currently installed to indicate the boundaries of the navigable water area. New marking posts and a new light beacon should be urgently provided together with repair to the rear beacon to ensure safe navigation of ferry boats.

3) Salelologa Port

1 Navigation Channel

The navigation channel in Salelologa Port is an essential facility for the ferry service connecting Salelologa Port and Mulifanua Port in Upolu Island.

The analysis of the sounding survey data shows that the navigation channel, including the eastern side of the turning basin, is not significantly silted and it is judged that the current conditions of the navigation channel allow normal operation of the ferry service. Dredging of the navigation channel has, therefore, been dropped from the restoration works in view of its low significance and effectiveness.

2 Navigation Aids (2 Light Beacons, 1 Light Post and 8 Marking Posts)

The light beacons, light post and marking posts are all important navigation aids indicating the direction and boundaries of the navigation channel.

As in the case of Mulifanua Port, the beacon and most of the marking posts were washed away and the lanterns of the beacons were also lost. No ball floats are currently

used as an emergency measure. The urgent restoration of beacons and posts is required to ensure safe navigation of the ferry boats.

4) Navigation Aids

1 Aleipata Lighthouse (1 No.)

This lighthouse fulfills the important function of indicating the eastern end of Upolu Island to cargo ships and ferry boats sailing for American Samoa. As the lantern was broken by the cyclone, the lighthouse has totally lost its function. The repair of the lantern and the door is urgently required to ensure safe coastal navigation.

2 Apolima Lighthouse (1 No.)

This lighthouse indicates the location of Apolima Island to those boats passing through the channel between Upolu Island and Savaii Island. The lantern and the door were broken by the strong wind. To secure safety of navigation of ship sailing for Apia Port, the urgent restoration work is required.

3 Malua Reef Lighthouse (1 No.)

This lighthouse serves for indicating the end of the reef to ships navigating along the north central coast of Upolu Island. The lantern is lost because of the strong wind. To secure safety of navigation of ship sailing for Apia Port, the urgent restoration work is required.

4 Navigation Aids in Asau Port (4 On-shore Beacons, 5 Sea Beacons and 8 Marking Posts)

The beacons and marking posts are important navigation aids indicating the direction and boundaries of the navigation channel to the ships calling Asau Port.

Except for one ground beacon located at the center, all the beacons were severely damaged by the strong wind and waves caused by the cyclone "Ofa" and all the marking posts were lost. The Government of Western Samoa, however, has given a low priority to the restoration of these beacons and marking posts as it believes that cargo transportation (timber and petrol, etc.) between Savaii Island and Upolu Island can be substituted by ferry boats and trucks. In view of the low priority, the restoration work for the beacons and marking posts in Asau Port has been dropped from the restoration items.

The above considerations are summarized as follows.

1 Dredging of the mooring basin for small boats in Apia Port and both the navigation channel and turning basin in Salelologa Port have been omitted in view of small siltation and resulting negligible effect to their use by tug boats and ferry boats.

2 Restoration of navigation aids in Asau Port has been omitted in view of low urgency and effectiveness.

The above examination results are summarized in Table 3-1. Those facilities ranked as grades A or B require urgent restoration work. While the restoration of those facilities ranked grade C, though being also important, have been dropped from the restoration items because of their relatively low urgency and effectiveness.

Table 3-1 Examination of Requested Facilities

Facility	Size & Contents of Facility: Request	Grant	Examination Criteria: Importance	Urgency	Effectiveness	General Evaluation	Remarks
1. Apia Port							
1 Causeway	90 m	as left	2	2	2	A	
2 Seawall	200 m	235 m	2	2	1	B	
3 Breakwater	60 m	265 m	2	2	1	B	const'd offshore
4 Basin for Small Boats	6,000 m^2		2	0	0	C	
5 Pilot Boats	2	as left	2	2	1	B	
6 Navigation Aids	2	as left	2	2	1	B	
7 Port Office Building	280 m^2	215 m^2	2	2	1	B	
8 Sheds No.1 & 3	7,000 m^2	1,450 m^2	2	2	1	B	partial repair
9 Wooden Fender	steel 90 m	wood 90 m	2	2	1	B	
2. Mulifanua Port							
1 Channel	25,000-30,000 m^2	32,000 m^2	2	2	2	A	
2 Ferry Ramp	24 m	as left	2	2	2	A	
3 3.5m Wharf	40 m	as left	2	1	1	B	partial repair
4 Seawall	250 m	150 m	2	1	1	B	partial repair
5 Navigation Aids	2 light beacons, 11 marking posts	as left	2	2	1	B	
3. Salelologa Port							
1 Channel			2	0	0	C	
2 Navigation Aids	2 light beacons, 1 beacon, 8 marking posts	as left	2	2	1	B	
4. Navigation Aids							
1 Aleipata Lighthouse	1	as left	2	2	1	B	
2 Apolima Lighthouse	1	as left	1	1	1	B	
3 Malua Reef Lighthouse	1	as left	1	1	1	B	
5. Asau Port							
1 Navigation Aids	9 beacons, 8 marking posts		1	1	0	C	

High	Medium	Low
2	1	0

3.2.5 Examination of the Request of Quarry Plant

The required capacities and other specifications of the crusher and ancillary equipment are detailed in Chapter 4, Basic Design and in this section, necessity of each equipment is examined.

The crushers and such ancillary equipment as loader and drill are provided in the existing quarries. However, they are all beyond economical service life and complete repair works to these equipment are impossible, therefore any of the existing equipment will not be included in the new quarry.

1) Crusher (100 t/h class, 1 No.)

The production capacity of crushed stone of the PWD would be recovered to a level of about 5 t/h if the quarry plants in Alafua and Olo will be repaired to resume production activity. The repaired plant will face frequent breakdowns and will not be able to meet the demand of crushed stone even for regular road maintenance work. Therefore, a new crusher is urgently required for all of the restoration works and new road construction works requiring stone materials. A quarry plant has been provided by the contractor for the road improvement project financed by the ADB which was commissioned in June, 1990. As development of a small quarry for each road construction work near the construction site will lead to environmental destruction, the PWD intend to develop a single large quarry plant to meet the stone demand for both Upolu Island and Savaii Island. A crusher is essential machinery to produce and supply crushed stone for all the planned restoration works and the planned production capacity of 100 t/h is reasonable as discussed in Chapter 4.

2) Generator (270 KVA, 1 No.)

Although power is supplied to the Alafua quarry where the introduction of the new quarry plant is planned, an electric

supply is presently restricted to about 8 hours/day, partly because of the damage to the power station by the cyclone "Ofa".

In addition, a high voltage fluctuation has caused frequent accidents. It is believed that some 5 years will be required to completely restore a satisfactory power supply situation. Consequently, the use of a diesel engine generator is planned for the project to supply power to the crusher.

3) Wheel-Loaders for Loading Raw Rock (2.4 m^3, 2 Nos.)

One wheel-loader is required to load blasted raw rock to the dump trucks from the cutting bench while another is required to feed the raw rock to the primary crusher hopper.

4) Dump Trucks (12 ton, 4 Nos.)

Dump trucks are required to transport raw rock from the cutting bench to the crusher. Special specification for a loading bed is adopted to load large raw rock weighing about 500 kg a piece.

5) Wheel-Loader for Loading Crushed Stone (1.7 m^3, 1 No.)

A wheel-loader is required to load the crushed stone to the customer's truck and also to handle crushed stone of various size in the stock yard.

6) Drills (63.5-90 m/m, 2 Nos.)

Two drills are required to feed raw rock to the crusher with production capacity of 100 t/h. A hydraulic type drill is more efficient and popular than an air driven type and has been selected.

7) Bulldozer (35 t class, 1 No.)

A bulldozer is used to cut and remove a surface soil and weathered soil covering raw rock. A 35 ton class bulldozer is

required for cutting hard weathered basalt. A bulldozer needs to be equipped with a blade to remove surface soil and a ripper for cutting work.

The equipment listed in 1) - 7) above is given the first priority.

8) Backhoe (1.0 m^3, 1 No.)

A backhoe is used to collect coral sand for concrete aggregate. The PWD plans to procure a large barge mounting a backhoe for collection of coral sand.

In addition to a barge and a backhoe, a tug boat, mooring quay for the barge, sand stockyard, sieving machine, pay loader and office building, etc. are required to produce sand aggregate. At present, coral sand is used as fine aggregate for concrete and is collected by a private company using a drag-line or a crane with clam-shell bucket in Mulinuu and Vaitele near Apia.

Since the collection site, supply and demand forecast and management system, etc. have not been finalized yet, the provision of a backhoe has been omitted from the project. The main purpose of the project, the introduction of a quarry plant to produce crushed stone has also contributed to this decision.

9) Workshop (380 m^2, 1 No.)

The PWD currently has a motor pool and workshop at Vaitele to store and maintain all machinery and equipment. All the machinery planned under the project can be repaired at this workshop and minor repairs can also be conducted at the quarry. As the Vaitele workshop is located only some 5 km north of the Alafua quarry, and capable of providing an efficient and reliable repair works, a workshop has been omitted from the project.

10) Small Truck with Crane (4 ton, 1 No.)

A truck with crane to be used for repair work in the quarry and also to change worn parts of a crusher, etc. is not frequently required, and it has been omitted from the project in preference of leasing as required which is more cost efficient.

11) Pick-Up Trucks (2 Nos.) and Station Wagon (1 No.)

The pick-up trucks will be used for transportation of such consumables as dynamite, fuel for machinery and spare parts, etc. while the station wagon is required for general administration purposes.

3.3 Outline of Project

3.3.1 Executing Agency and Management System

1) Port Facilities

Apia Port is operated by many governmental and private organizations and for efficient port management, an organization like "port authority" integrating all the port activities is recommended.

All ports in Western Samoa are under the control of the Ministry of Transport and the Shipping Department with 117 staff members, including the Director of Shipping (served by secretary of Minister of Transport), of which 23 staff members are assigned to sea duties. In addition, a marine consultant is provided by the Government of New Zealand. The organization of the Ministry of Transport and Shipping Department are shown in Fig. 3-2 and Fig. 3-3 respectively.

2) Road Facilities

The PWD consists of 7 departments, with a total of 236 staffs as shown in Fig. 3-4. The Civil Department consists of

the Construction Section, Design Section and Quarry Section with 83 staff members.

On completion of the construction of the planned quarry plant, the plant will be operated by 30 staffs under the instruction of the Chief Civil Engineer of the Civil Department as in the case of existing plants.

The management system planned by the PWD for the new quarry plant is shown in Fig. 3-5.

3.3.2 Outline of the Planned Port Facilities

Detail of the planned port facilities is described in Chapter 4, and the outline is as follows.

Causeway		88 m	(Apia Port)
Seawall		235 m	(")
Breakwater		265 m	(")
Dredging		32,000 m^3	(Mulifanua Port)
Ferry Ramp		24 m	(")
-3.5m Wharf		40 m	(")
Seawall		150 m	(")
Navigation Aids,	Beacon	2 Nos.	(")
	Marking Post	11 Nos.	
Navigation Aids,	Beacon	2 Nos.	(Salelologa Port)
	Marking light	1 No.	(")
	Marking Post	8 Nos.	(")
Pilot/Work Boat		2 Nos.	(Apia Port)
Navigation Aids		2 Nos.	(")
Marine Office		215 m^2	(")
Wooden Fender		90 m	(")
Lighthouse		1 No.	(Aleipata)
		1 No.	(Apolima)
		1 No.	(Malua Reef)

3.3.3 Outline of Planned Quarry Plant

The types and specifications of the planned equipment are described in detail in Chapter 4 and are outlined as follows.

1	Crusher	100 t/h	1 No.
2	Generator	270 KVA	1 No.
3	Wheel-Loaders (for raw rock)	2.3 m^3	2 Nos.
4	Dump Trucks	12 ton	4 Nos.
5	Wheel-Loader (for crushed stone)	1.7 m^3	1 No.
6	Drills	63-90 m/m	2 Nos.
7	Bulldozer	35 ton	1 No.
8	Pick-Up Trucks	1 ton	2 Nos.
9	Station Wagon	4,000 cc	1 No.

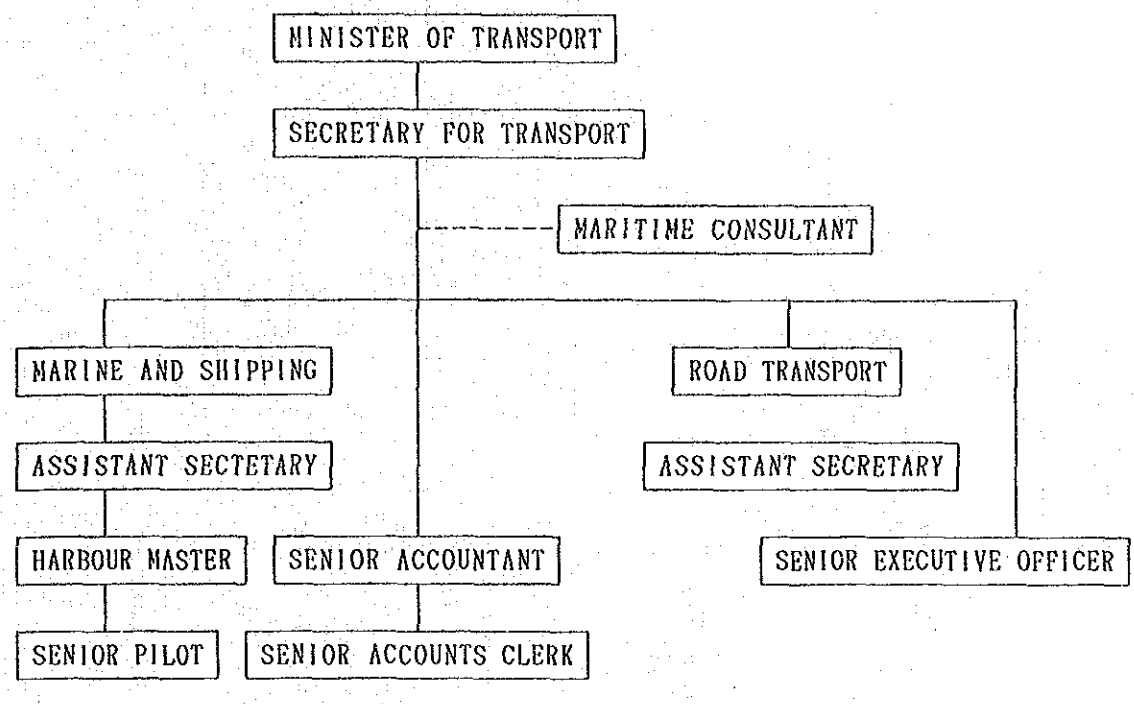


Fig. 3-2 Organization Chart, Ministry of Transport

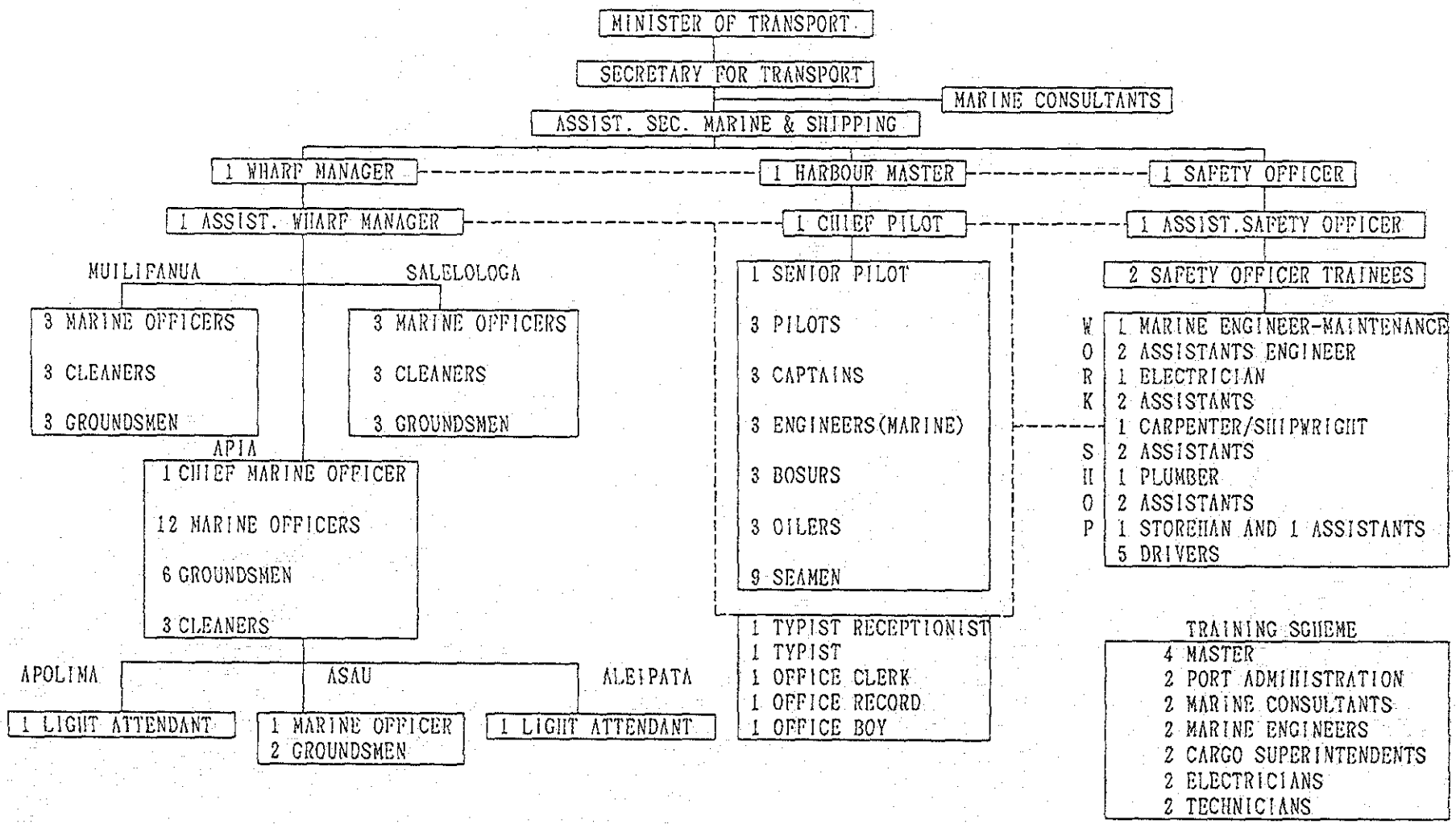


Fig. 3-3 Organization Chart, Ministry of Transport Marine and Shipping

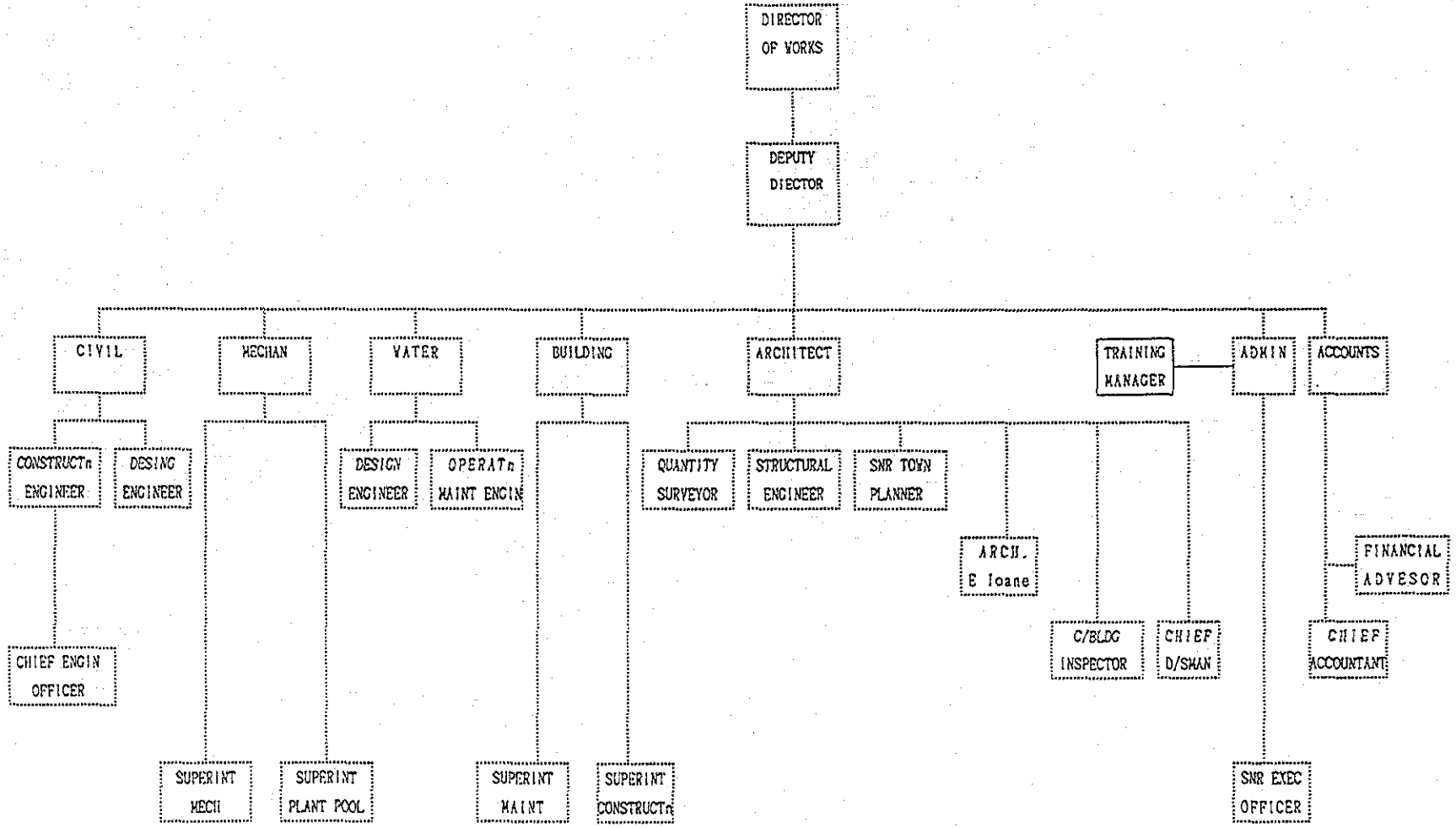


Fig. 3-4 Organization Chart, Public Works Department

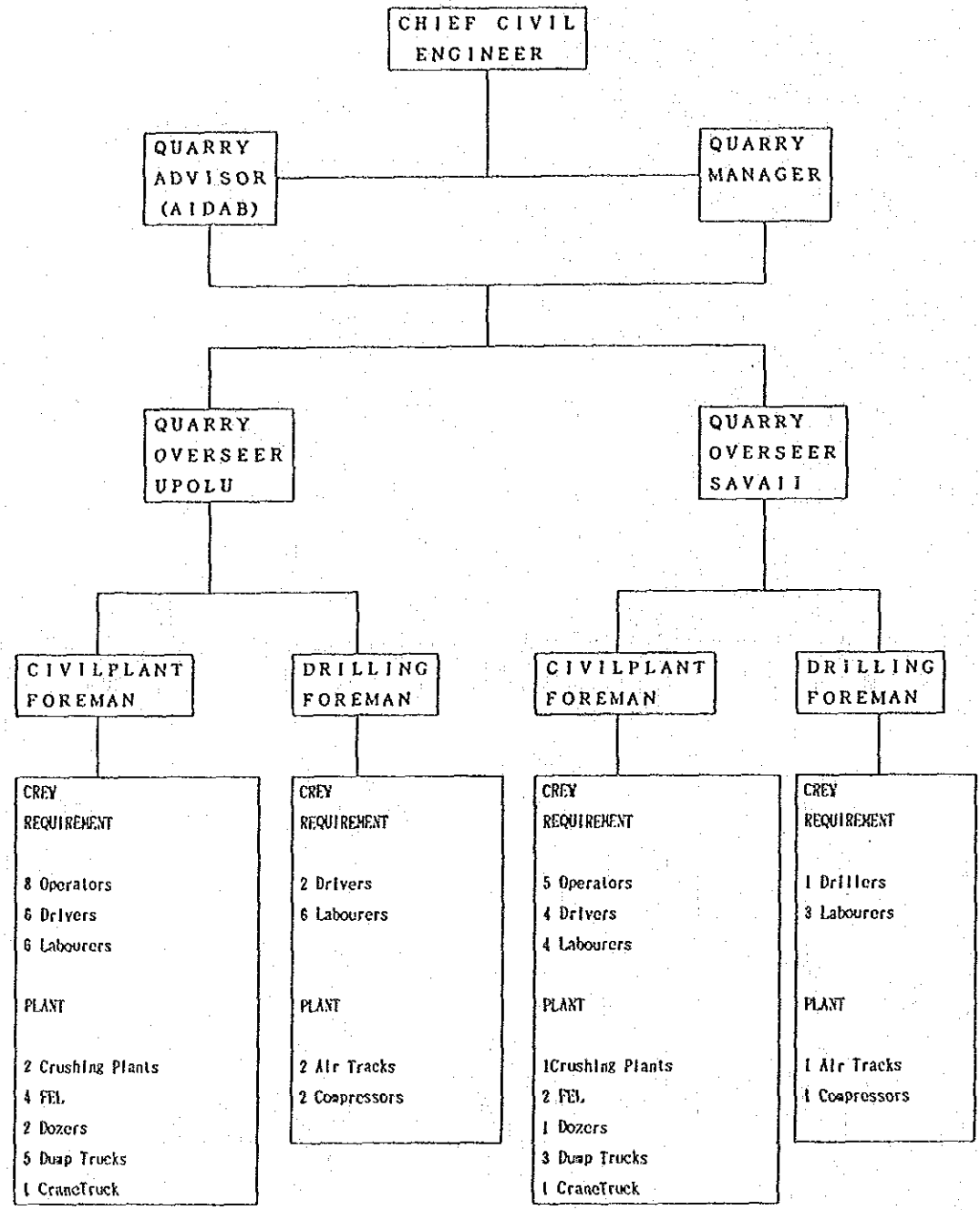


Fig. 3-5 Organization Chart, New Quarry

3.3.4 Administration and Operation Plan

(1) Port Facilities

Apia Port is planned to be administered and operated by a proposed new organization "Port Authority" starting from 1991 to efficiently handle increasing cargoes and maintain the port facilities. The existing organization will not require any reinforcement in work force even after the restoration works. The balance of operation income and expenditure is estimated as follow.

Income and Expenditure (1000 WS$)

Income		Expenditure	
Cargo Storage	558	Salary	437
Wharfage	371	Maintenance	577
Warehouse	140	Operation	214
Lighting/Pilotage	106	Office	94
Others	283	Others	136
Total	1,458		1,458

(2) Quarry Plant

It is planned that the quarry plant be operated on a self-financing basis by a corporation to be established under the jurisdiction of the PWD. Crushed stone will be sold to government agencies and public projects at cost. The expected annual balance of income and expenditure for this corporation is examined below.

1) Operating Expenses

a) Personnel Cost

A total of 31 staffs will be employed to operate the new quarry plant and their respective wages will be as follows.

	Number	Hourly Wage (WS$)	Annual Wage (WS$)
Overseer	1	13.0	31,200
Drilling Chief	1	11.0	26,400
Drivers	2	7.0	33,600
Labourers	6	3.5	50,400
Crushing Chief	1	11.0	26,400
Operators	8	7.0	134,400
Drivers	6	6.0	86,400
Labourers	6	3.5	50,400
Total	31		439,200 (WS$)

b) Equipment Depreciation/Maintenance Cost and Fuel Cost

	Number	D/M Cost	Fuel Cost	Total (WS$)
a. Crusher	1	252,000	-	252,000
b. Generator	1	16,671	110,000	126,671
c. Loaders	2	101,333	63,500	164,833
d. Dump Trucks	4	143,700	90,000	233,700
e. Loader	1	37,167	23,250	60,417
f. Drills	2	151,146	28,000	179,146
g. Bulldozer	1	113,669	56,750	170,417
h. Trucks	2	7,000	12,500	19,500
i. Vehicle	1	7,000	6,250	13,250
Total				1,219,934 (WS$)

c) Consumables Including Explosives 30,573 (WS$)

d) Office Expenses 17,587 (WS$)

Total Annual Expenses

Personnel Cost	439,200
Depreciation, Maintenance and Fuel Costs	1,219,934
Consumables Including Explosives	30,573
Office Expenses	17,587
Total	1,707,294 (WS$)

2) Operating Income

The annual income of the corporation is estimated below based on the expected annual production volume and the provisional new prices set by the PWD.

Stone Diameter (m/m)	Production Volume (m^3)	Unit Price (WS$/$m^3$)	Sales Income (WS$)
40 minus	16,400	22.0	360,800
20 minus	11,100	37.5	416,250
20	6,400	37.5	240,000
10	10,600	37.5	397,500
7	2,600	40.0	104,000
various	1,800	37.5	67,500
Total			1,586,050

3) Operating Balance

Based on the estimations in 1) and 2) above, the expected balance will be 121,244 WS$ in the red. This deficit can be covered by raising prices by about 8%.

A private concrete company which owns a quarry plant is currently selling crushed stone at 50 WS$/CY (65 WS$/m^3). In

view of this current market price, it is deemed appropriate to raise the intended crushed stone price of 37.5 WS$/$m^3$ of the PWD by about 8% to 40 WS$/$m^3$ to enable the operation of the new public corporation to be profitable or at least to break even.

3.4 Technical Cooperation

With construction of the new quarry plant, the production capacity of crushed stone in Western Samoa will greatly increase, necessitating a corresponding expansion of the operating organization and consolidation of the management system. The PWD plans to establish a corporation to achieve efficient operation of the quarry plant on a self-financing basis.

At present, the quarry is operated by Samoan engineers under the supervision of the chief engineer of the PWD. An Australian expert of quarry plant has been supervising improvement of the existing facilities, preparations for the new quarry plant, preparations for enacting regulations relating to handling of explosives and construction of an explosive storage, etc. since May, 1990. Although the PWD has requested the Government of Japan to dispatch a similar expert as a Japan overseas volunteer, this request has not yet been realized. The PWD believes that 4 - 6 weeks technical training/instruction will be required with regard to the installation, operation and maintenance of the plant before the full takeover of the plant by Western Samoan staff.

CHAPTER 4

BASIC DESIGN

CHAPTER 4 BASIC DESIGN

4.1 Design Policies

In this chapter, the results of basic design study on the project components which have been judged to be necessary in the preceding chapters are presented in regards to the structural type, sectional drawing and construction method.

In the basic design, the following basic policies are taken into consideration, in addition to the request of the Government of Western Samoa, the conditions of damages, the restoration plans and the local construction conditions:

1) The restoration works should not disturb the daily port operation.

2) The structures should be simple in type, be quickly constructed and be easily maintained by the local workers.

3) The damaged port facilities shall be restored to the conditions before the cyclone, while the crushing plant shall be designed to have production capacity enough to meet the demand of crushed rock required for the restoration works.

4) Utilization of local materials and manpower should be maximized while the construction cost and period should be minimized through due consideration of local condition of technical skill.

5) In designing, Japanese codes and standards shall be followed for port facilities.

4.2 Natural Conditions

In this section the natural conditions of the project sites are presented as the basis for the detailed design to be given in the following sections. Natural conditions cover such items as geological and topographical data, meteorological data, oceanographic data, as well as soil boring data. The bathymetric survey data and soil boring data obtained from the site survey during the basic design study are given in 4.2.3 and 4.2.4.

4.2.1 Oceanographic Conditions

(1) Current

Western Samoa is located within the band of the south subtropical current running from east to west. The current speed around the Samoan Islands ranges from 16 km to 20 km per day throughout the year. However Apia Port is not affected by the current because of offshore reef surrounding the harbour.

(2) Tide

Tidal data have been recorded at the Tide Station in Apia Port, and the following tides are defined.

Highest Astronomical Tide	(HAT)	+1.2 m
Mean High Water Spring	(MHWS)	+1.0 m
Mean High Water Neap	(MHWN)	+0.8 m
Mean Sea Level	(MSL)	+0.5 m
Mean Low Water Neap	(MLWN)	+0.2 m
Mean Low Water Spring	(MLWS)	+0.0 m (Chart Datum)
Lowest Astronomical Tide	(LAT)	-0.2 m

(3) Waves

Apia Port is well protected during the season of southeasterly trade winds, from April through October, since its entrance opens to north. From November to March, northeasterly waves and swells enter the harbour through the wide entrance, and agitate the inner harbour.

The following wave occurrence rate is analyzed based on the wind data recorded at Apia and wave data recorded off Apia Port by the U.S. Navy.

Wave height	Over 1 m to 2 m	32 days
	Over 2 m to 3 m	16 days
	Over 3 m to 4 m	8 days
	Over 4 m	3 days

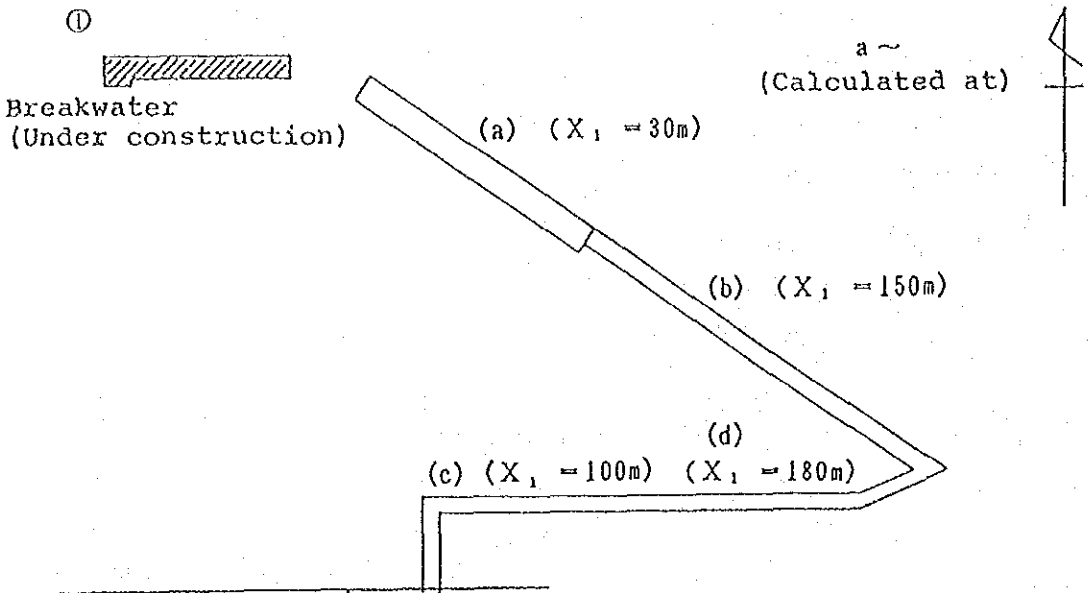
The maximum wave height off Apia Port is estimated by computer simulation as below, on the assumption that the largest cyclone recorded in the past 40 years proceeded on a course affecting Apia Port most seriously.

Direction	North
Wave height	7.0 m
Period	10 sec

The waves generated by the cyclone "Ofa" have been hindcast by a computer simulation. The wave dimensions and raise of water level are compared between the design wave of the on-going project and the waves generated by the cyclone "Ofa" at the places of the breakwater, seawall and causeway.

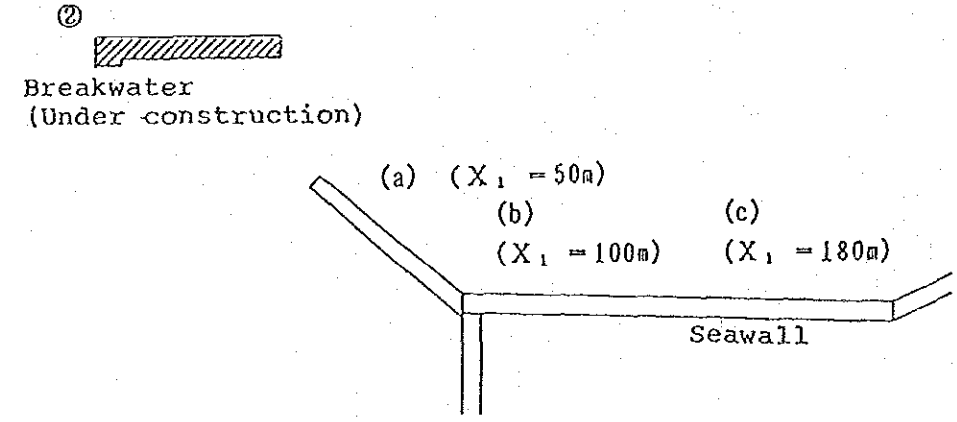
	Deepwater Wave		
Wave	Direction	Height	Period
1. Cyclone "Ofa"	N	8.6 m	12 Sec
2. Present Design Wave	N	7.0 m	10 Sec

Fig. 4-1 illustrates the results of calculation. The design wave for the breakwater and seawall is superposition of waves propagating through shallow reef area from North and Northwest and the design wave height in front of these facilities is about 20% higher for the waves generated by the cyclone "Ofa" than those of the present design wave. While,



Location	Wave	Wave
(a)	H1/3=2.93m η(X₁)=0.56m	H1/3=2.44m η(X₁)=0.44m
(b)	H1/3=1.80m η(X₁)=0.77m	H1/3=1.52m η(X₁)=0.59m
(c)	H1/3=0.87m η(X₁)=0.42m	H1/3=0.77m η(X₁)=0.32m
(d)	H1/3=0.81m η(X₁)=0.43m	H1/3=0.62m η(X₁)=0.32m
	η(X₂), X₂ =700 =0.84m	η(X₂), X₂ =700 =0.63m

H1/3 : Design Wave
η : Raise of Water Level
X₁ : Distance from West Reef Edge
X₂ : Distance from North Reef Edge



Location	Wave	Wave
(a)	H1/3=2.08m η(X₁)=0.50m	H1/3=1.70m η(X₁)=0.30m
(b)	H1/3=2.12m η(X₁)=0.72m	H1/3=1.76m η(X₁)=0.56m
(c)	H1/3=1.68m η(X₁)=0.79m	H1/3=1.44m η(X₁)=0.60m
	η(X₂), X₂ =700 =0.84m	η(X₂), X₂ =700 =0.63m

H1/3 : Design Wave
η : Raise of Water Level
X₁ : Distance from West Reef Edge
X₂ : Distance from North Reef Edge

Fig. 4-1 Wave Height/Raise of Water Level Calculated

raise of water level is mainly generated by the waves from North and is about 30% larger in the case of the cyclone "Ofa". The wave height in front of the causeway is calculated by superposing diffraction and overtopping waves through the breakwater presently under construction as follow.

Cyclone "Ofa"	H 1/3 = 2.67 m
Present Design Wave	H 1/3 = 2.46 m

Though the waves generated by the cyclone "Ofa" is the largest in 100 years, the wave dimensions in front of the port facilities are not of significant difference. Therefore, the present design wave conditions are adopted in this particular project.

While for the raise of water level, since that caused by the cyclone "Ofa" is about 30% larger, the value of 84 cm is adopted. A total raise is addition of raises of about 50 cm caused by low air pressure and wind effect to the above as below.

Breakwater, Seawall	0.84 + 0.5	=	1.4 m
Causeway			0.5 m

(4) Siltation

Apia Port has two sources of sediment, the Vaisigano River and the Mulivai Stream, the main source being the former.

By comparison of sounding data of 1981 with that of 1987, the siltation volume in the turning basin in front of the main wharf (with a radius of 200 m) is estimated at 9,500 m^3/year, i.e. 7.5 cm/year in average, and the maximum siltation rate is estimated at 12 cm/year requiring a maintenance dredging possibly once in 10 years.

4.2.2 Earthquake

The islands of Western Samoa are located at the north end of the Tonga-Kermadec Trench, the northeast side of the Marshall line, the boundary between the Australian plate and the Pacific plate. Thus the islands are often hit by earthquakes of M7 due to the seismic activities of the Circum-Pacific Earthquake Belt. In 1917, a strong earthquake of M8.3 was observed about 200 km south of Western Samoa. Therefore, a seismic factor of 0.15 is adopted for the design of structures.

4.2.3 Bathymetric and Topographical Surveys

(1) Apia Port

1) Causeway

The backfill materials of the causeway were washed away for the area of 40 m by 10-40 m and the 1.0 t armour stones were dislodged and moved landwards in disorder by about 20 m. The revetment covering the slope of the causeway collapsed for the entire length of about 90 m and the water depth near the main wharf became about -3.0 m and about -1.0 m in front of the coconut tank yard.

2) Seawall

The seawall from the old breakwater to the Shed No.3 was scoured for the length of 200 m and the backfill materials were washed 5-10 m landwards.

3) Mooring basin for small boat

The water area which was deeper than -5.0 m became shallow by about 1.0 m while the water area of -3.0 ~ -5.0m deep previously became 0.5 ~ 1.0 m deeper than before. The soil washed away from the causeway and the container yard is judged to have deposited into the area which was deeper than -5.0 m.

(2) Mulifanua Port

1) Seawall

The seawall north to the ferry terminal collapsed for the section of about 100 m out of the total length of 200 m and the road along the back of the seawall was damaged on its pavement for 50 m of one lane of 3 m.

2) Siltation of the Ferry Channel

Fig. 4-3 shows siltation of the ferry channel in Mulifanua Port. Siltation is notable in the northern half of the channel for about 740 m from the front of the port to offshore.

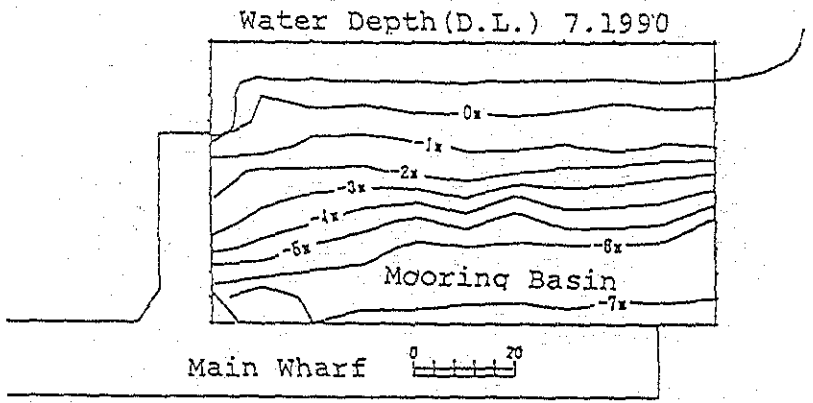
As shown by the typical cross sections No. 1, No. 2 and No. 3, about 2 m thick deposit is observed in the turning basin and the northern half of the channel from 1986 when the channel was constructed. A small siltation is observed on the southern slope of the channel.

Approximately 23,000 m^3 of soil deposits above the design water depths (-3.5 m and -3.2 m) of the ferry channel in Mulifanua Port.

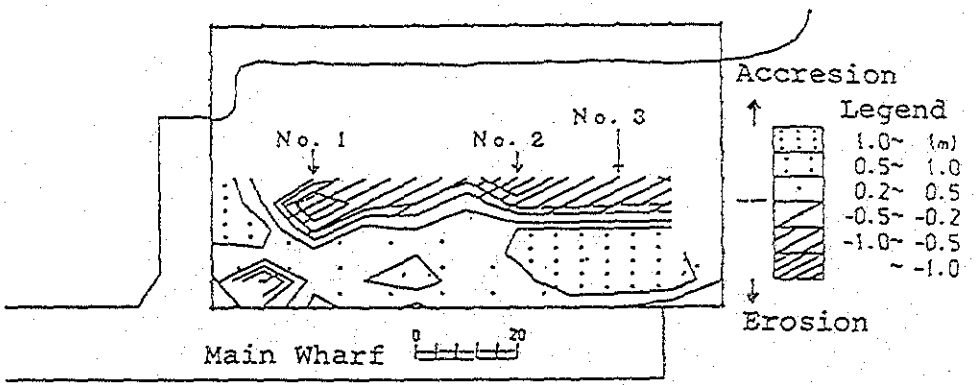
These conditions suggest that high waves at the time of the cyclone "Ofa" which came from the north whirled up the bottom materials on a shallow reef north to the channel, carried them to the channel, and then dropped them down in the channel where the water is deeper.

The deposit sand on the surface layer of ST.1 - ST.6 shown in Fig. 4-3 was sampled and analyzed for grain size distribution, and all the samples were fine sand of about 1.5 mm in median diameter containing thin coral pieces of about 5 mm in diameter.

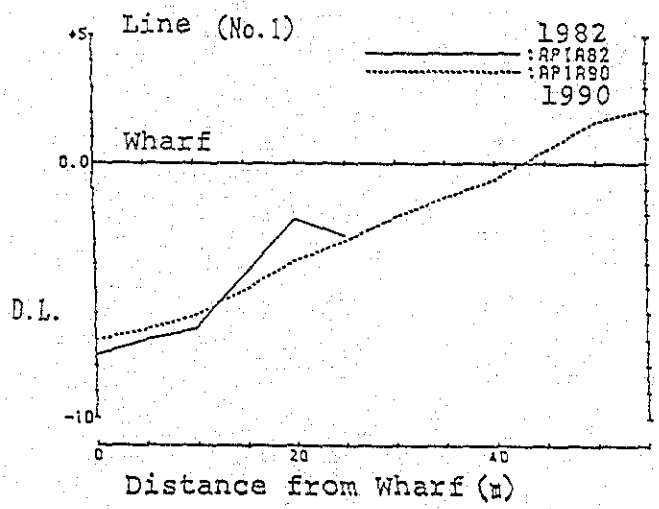
Fig. 4-2 Water Depth in Mooring Basin, Apia Port

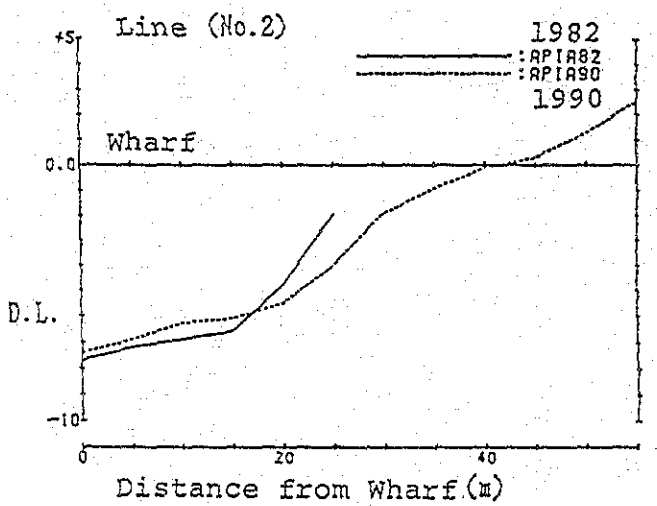


Water Depth in Mooring Basin



Change of Water Depth form 7, 1982 to 7, 1990





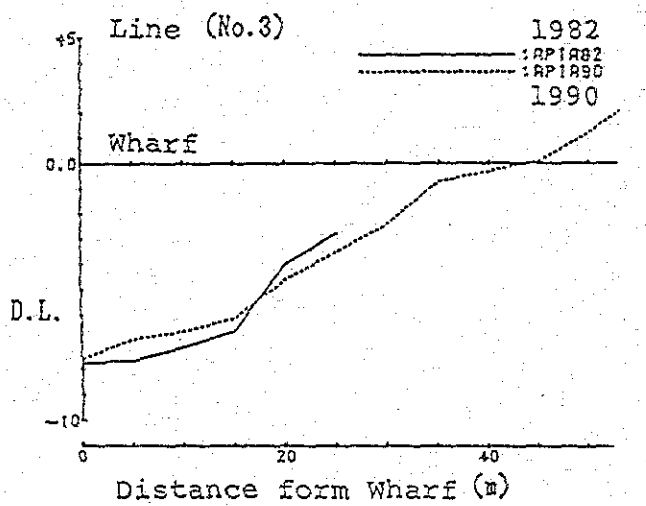
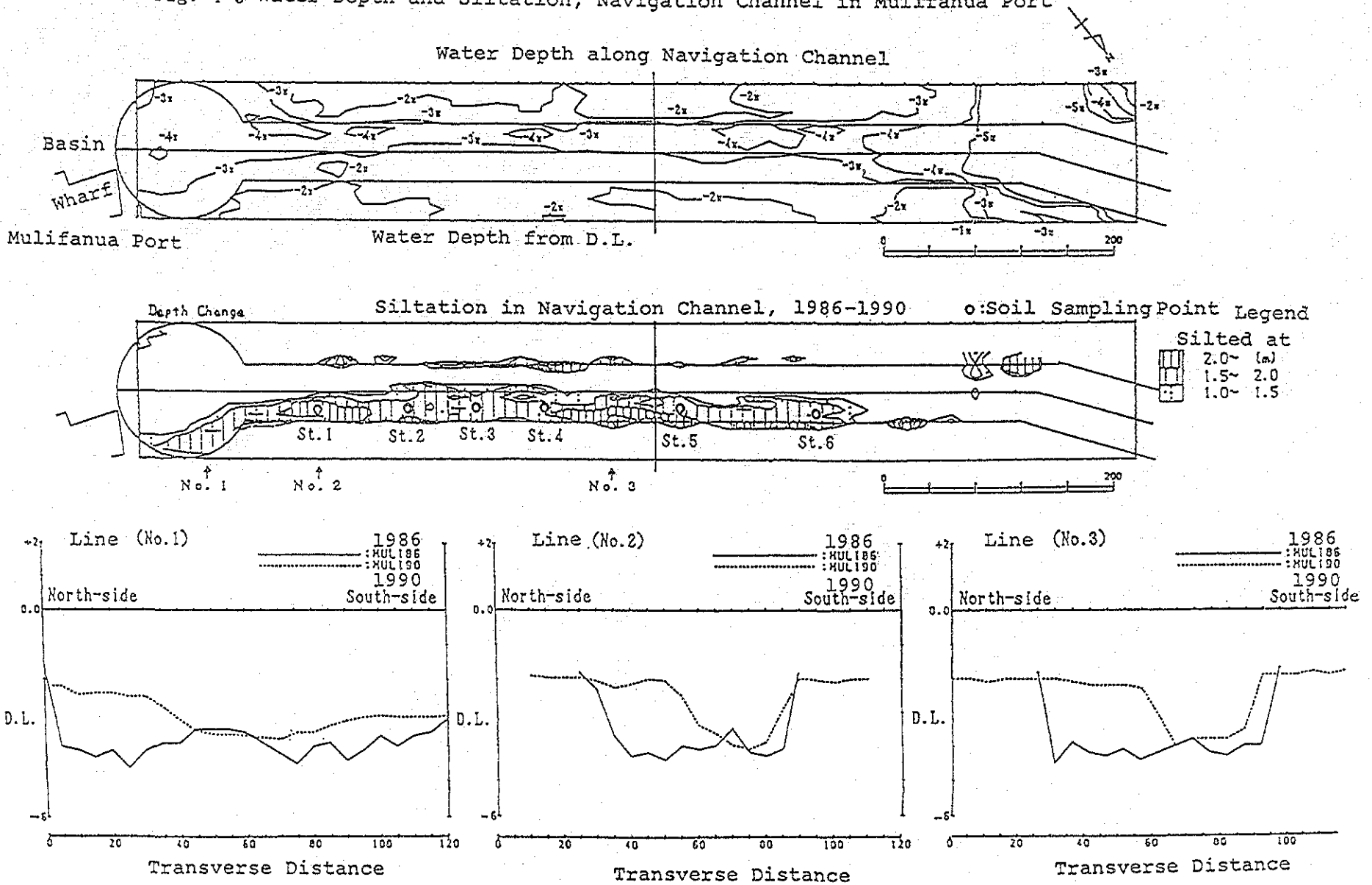


Fig. 4-3 Water Depth and Siltation, Navigation Channel in Mulifanua Port



Large stones or rocks which may hinder dredging operations are not observed in the channel.

(3) Salelologa Port

According to the sounding survey of the ferry channel in Salelologa shown in Fig. 4-4, any siltation affecting a ferry operation has not been observed even after the cyclone "Ofa".

The grain size analysis of bottom sediments revealed that all the samples consisted of silt and that there was no soil carried in as in the case of Mulifanua Port.

This is attributed to the topological condition of Salelologa Port which was sheltered from the incoming waves of the cyclone "Ofa" from the north.

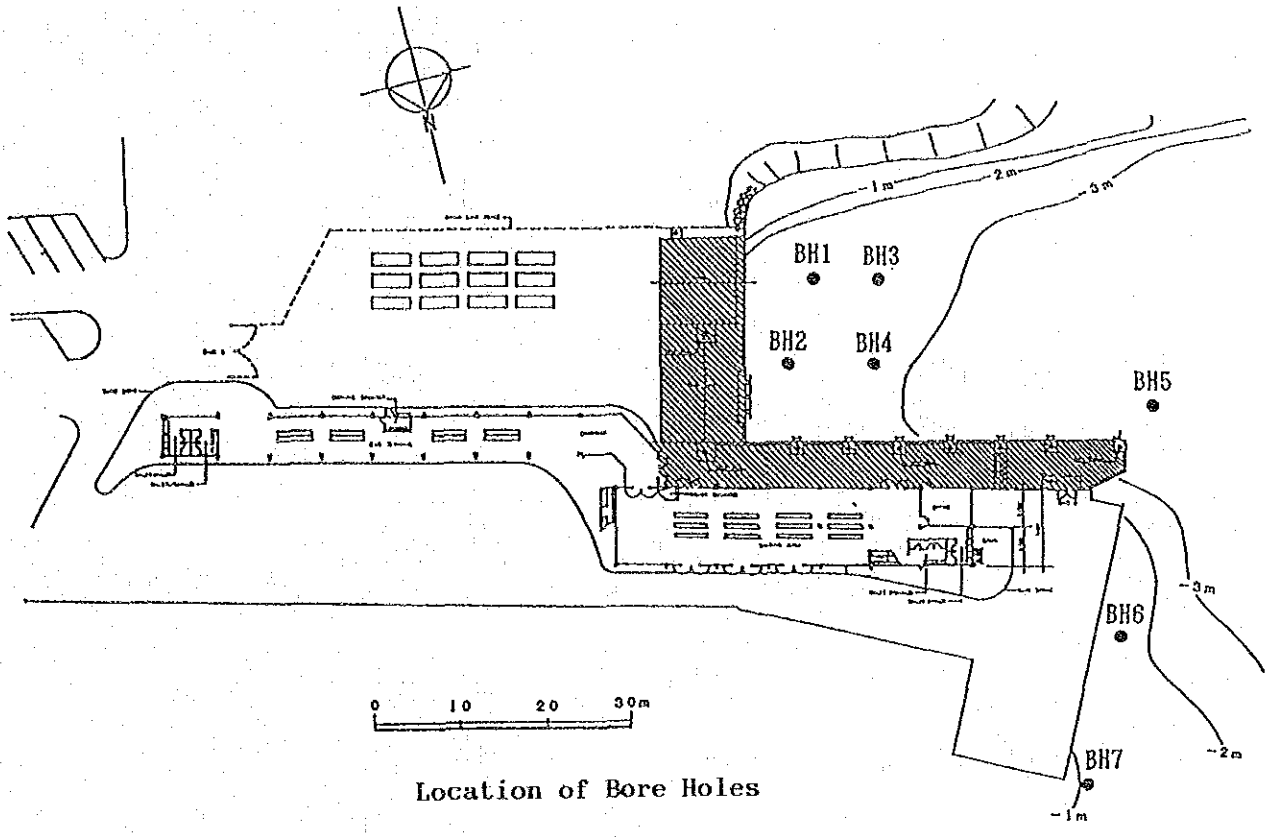
4.2.4 Soil Condition

(1) Mulifanua Port

The soil survey was conducted near the ferry ramp and the -3.5 m wharf in order to examine the properties and distribution of the sub-surface soil. The data are required for basic designs of the restoration plans of the ferry ramp in Mulifanua Port.

In front of the ferry ramp, a total of 11 standard penetration tests were conducted with 4 bore holes for the total penetration depth of 20 m to the depths of 3.5 m, 5.5 m, 7.0 m and 4.0 m below the sea bed.

In front of the -3.5 m wharf, a total of 11 standard penetration tests were conducted with 3 bore holes for the total penetration depth of 14.0 m to the depths of 4.5 m, 4.5 m and 5.0 m below the sea bed.



Location of Bore Holes

Profile

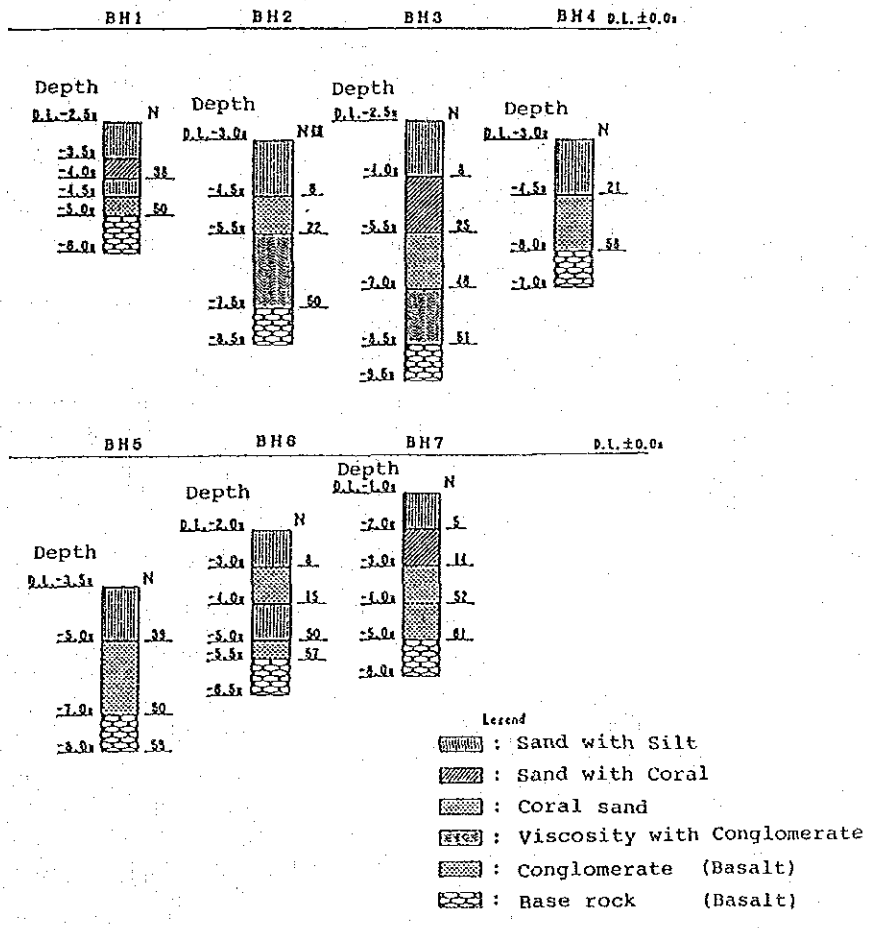
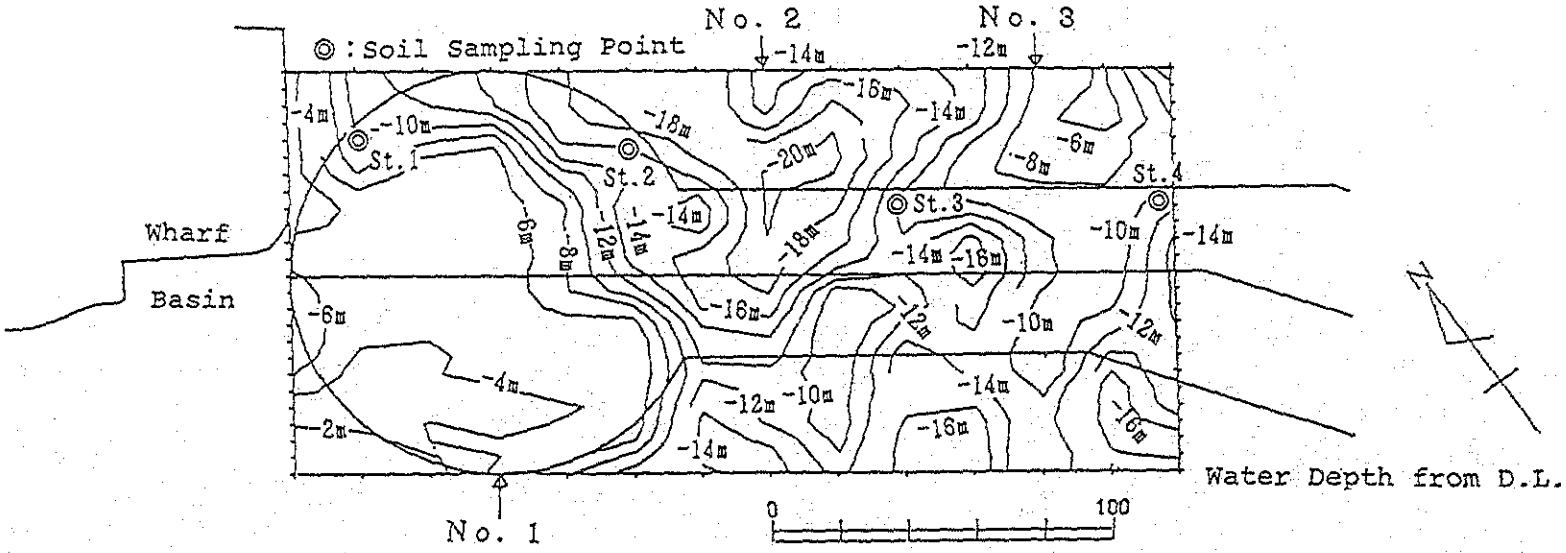
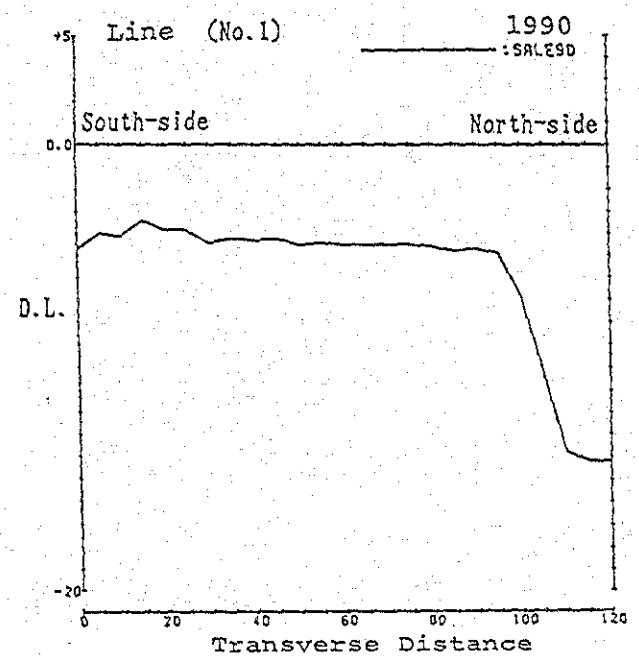
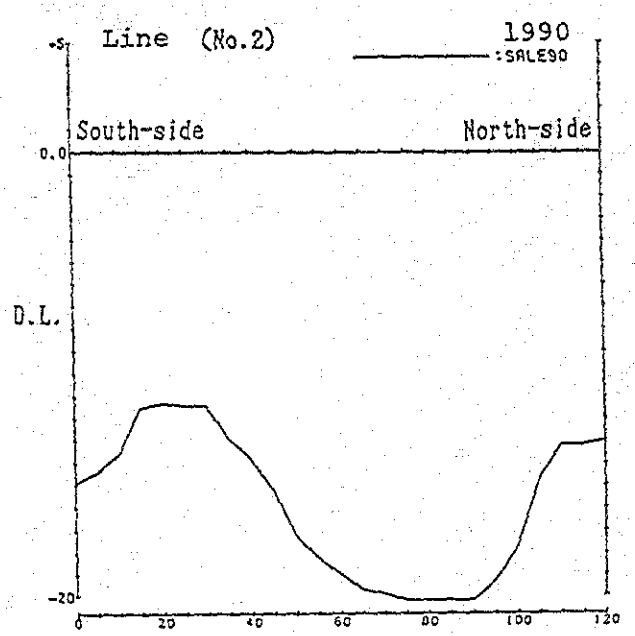


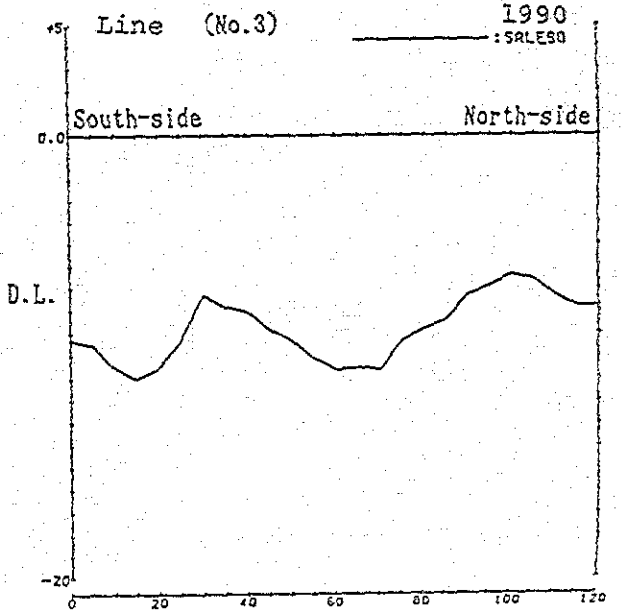
Fig. 4-4 Soil Investigation, Mulifanua Port

Fig. 4-5 Water Depth, Navigation Channel in Salelologa Port









Bore hole locations and the soil profiles are shown in Fig. 4-5. According to the figure, there exists the basalt rock bed at a very shallow depth of 3.0 to 6.0 m below the sea bed.

The rock is covered with very loose silty sand of the top layer to about 1.5 m below the sea bed, and the second layer consists of fine sand containing small coral pieces with N value of about 20.

(2) Property of Rock in the Quarry

The Alafua quarry is located about 6 km south to Apia downtown on the ridge between Papaseea and Samoi Streams. The rock in the quarry is hard basalt with specific gravity of 3.05 and does not contain vapor or gas being suited to stone materials for road construction and general concreting works. Also, the rock layer does not include soft or weathered rock much and drilling and blasting operations are expected to be efficient.

4.3 Basic Plan

4.3.1 Design of Port Facilities

(1) Facilities to be restored

The facilities which need to be reconstructed under the present project are the followings as discussed in the previous chapter.

1) Apia Port

a) Causeway

The causeway which has been washed away will be rebuilt in order to restore access to the main wharf and also to facilitate safe and efficient cargo

operation and smooth execution of the on-going project.

b) Seawall

The damaged seawall will be repaired in order to secure safety of such facilities as the coconut oil tanks, sheds, container yard in the port.

c) Breakwater

The breakwater which has been washed away will be rebuilt in order to improve the calmness in the waters near the main wharf and in front of the causeway. The new breakwater will be aligned offshore along the entire length of the seawall in order to complement the functions of the seawall mentioned in b) above.

d) Pilot/work boat

Damages to the boats and outboard engine will be repaired in order to facilitate smooth port operations such as pilotage and line handling.

e) Navigation aids

The marking light which has been destroyed will be rebuilt and the damaged light buoy will be repaired in order to secure safety in access to the port for cargo vessels and fishing boats.

f) Marine Office

The building which has been damaged beyond repair will be demolished and a new office will be built in order to facilitate smooth port operations such as entry/departure of vessels, pilotage and operation of tugboats.

g) Sheds No. 1 and No. 3

Damages to the roof, walls and doors of the sheds will be repaired to prevent pilferage and damages to the cargo.

h) Wooden fenders

Damaged wooden piles and beams will be repaired in order to secure safe mooring and berthing of tug boats and pilot boats.

2) Mulifanua Port

a) Navigation channel

The navigation channel and turning basin which have been silted will be dredged in order to save the time and cost of transportation by resuming normal ferry operation.

b) Ferry ramp

The ferry ramp which has been damaged will be restored in order to secure safe operation of the ferry boat and to resume normal ferry operations.

c) -3.5 m wharf

The concrete apron, oil tanks and fence behind the wharf were damaged and will be restored for servicing local cargo and fishing boats.

d) Seawall

North and south seawalls shall be repaired to secure safety of the onshore facilities.

e) Navigation aids

All the navigation aids damaged shall be rebuilt or repaired to secure safety for ferry operations.

3) Salelologa Port

a) Navigation aids

All the damaged navigation aids shall be rebuilt or repaired to secure safety of ferry operation.

4) Navigation aids

a) Aleipata

The lantern and door of the lighthouse which has been damaged will be repaired to secure safety of vessels sailing along the eastern coast of Upolu Island.

b) Apolima

The lantern and door of the damaged lighthouse will be repaired to secure safety of vessels passing through the strait between Upolu and Savaii Islands.

c) Malua Reef

The lantern of the damaged lighthouse will be repaired to secure safety of vessels passing along the north center coast of Upolu Island.

(2) Design of Port Facilities

Apia Port

1) Causeway

a) Restoration

Backfill materials have been completely washed away from the causeway and rubble stones of the revetment are scattered. A new revetment will be rebuilt at the present site and scoria will be used as backfill material.

The scope of restoration work shall be as follows.

i. The causeway shall have the trapezoidal shape, and extend for about 40 m in length and 10 - 40 m in width.

ii. The revetment for the causeway shall extend for 88 m (55 m for the causeway and 33 m for the slope protection for the coconut tank yard).

iii. Paving work on the causeway is not included in the restoration work, since it will be carried out by the ADB Container Park Project.

b) Design conditions

Design conditions for the revetment of the causeway are set as follows according to the natural conditions described in 4.2 of the present chapter.

i. Water level

HHWL	+ 1.5 m
HWL	+ 1.0 m
LWL	+ 0.0 m

ii. Waves

Causeway	H1/3 = 2.50 m, T1/3 = 10 sec
Tank Yard	H1/3 = 2.00 m, T1/3 = 10 sec

iii. Installation depth

Causeway	-3.0 m
Tank Yard	-1.0 m

iv. Foundation

The foundation is good with coral reef at both locations.

c) Structural design

The revetment shall be rubble slope structure similar to the design before the disaster.

The slope of causeway will be protected by three layers of rubble mound, armor stones, and then

concrete blocks. The revetment protecting the coconut tank yard will be two layers of rubble mound and armor stones because the design wave is smaller there. At the end of the causeway joining the main wharf, a gravity type wall will be erected with L-shaped blocks and in-situ concrete.

The crown heights of the revetment will be as follows.

i. The causeway shall meet the condition that substantial part of the waves will not overtop the causeway:

0.8 x H1/3 above the design HWL = +3.5 m.

ii. The revetment of the coconut tank yard shall meet the condition that overtopping of the waves will be prevented as much as possible:

1.0 x H1/3 above the design HWL = +3.5 m.

Required weight of the concrete blocks for the revetment of the causeway is calculated as 1 - 1.5 tons, but 4 ton blocks will be used in view of using the blocks of the same size required at the joint to the main wharf as well as for the breakwater.

2) Seawall and Breakwater

a) Restoration

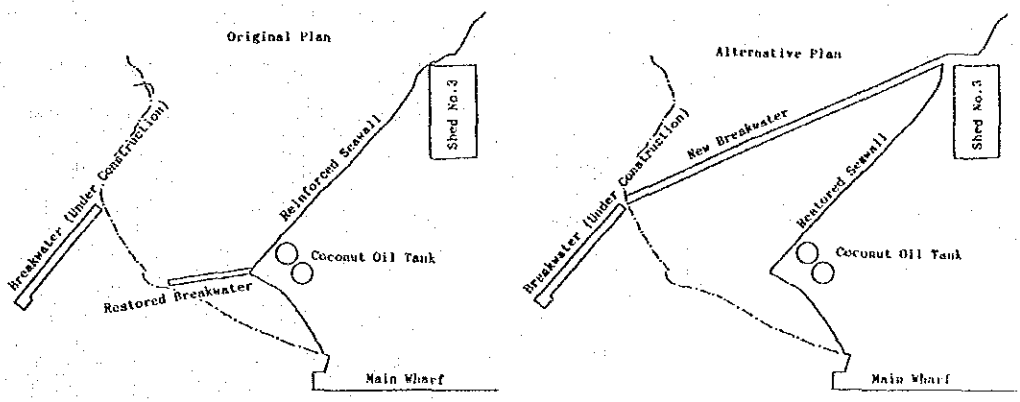
The damaged east seawall can be restored to the previous section in the previous location, but reinforcement is required for protection of the coconut tanks and the Shed No. 3.

Reconstruction of the breakwater is very expensive and should be planned by taking into consideration the restoration work of the above east seawall. In the case that a new breakwater will be constructed offshore along the frontage of the east seawall for the entire length, the section of the seawall can be

smaller and less expensive because of wave height decreased by the breakwater. This proposal should be reviewed along with the restoration plan for the east seawall.

We therefore compare two plans; the original plan of restoring the east seawall and the breakwater in the previous location, and the alternative plan of constructing a breakwater along the line connecting the corner of the Shed No. 3 and the breakwater which is being constructed under the Apia Port Development Project, and restoring the east seawall in the previous location. (Refer to Fig.4-6)

The table below shows the results of comparison of the two plans in respect of their scope, functions and construction costs. The alternative plan is judged to be advantageous.



	Original Plan	Alternative Plan
i. Scope		
* Breakwater	length (new) : 60 m	length (new) 265 m (100 m + 165 m)
* Seawall	length (reinforced) : 235 m	length (original section): 200 m length (reinforced) : 35 m
ii. Functions		
* Breakwater	Protecting causeway and main wharf	Protecting causeway, main wharf and eastern seawall
* Seawall	Can prevent wave overtopping	Same as the original plan
iii. Useage	The crown height of the seawall will be as high as +4.4 - 4.7 m, and will not trouble passage of wind and the view	The crown height of the seawall will be low at +3.0 - +3.2 m, and will cause no problems in use. Future expansion of the container yard will be easy.
iv. Construction cost	1.0	1.0

Through the consideration above, it is concluded that the alternate plan should be adopted for restoring the breakwater which has been washed away and the east seawall.

b) Design conditions

Design conditions for the east seawall and the breakwater are set as follows according to the natural conditions discussed in 4.2 of this chapter.

i. Water level

HHWL	+2.5 m
HWL	+1.0 m
LWL	+0.0 m

ii. Waves

East seawall

L21 = 0 - 60 m, H1/3 = 0.8 m, T1/3 = 10 sec
L22 = 60 - 200 m, H1/3 = 0.6 m, T1/3 = 10 sec
L23 = 200 - 235 m, H1/3 = 1.5 m, T1/3 = 10 sec

Breakwater

L30 = 0 - 20 m, H1/3 = 2.8 m, T1/3 = 10 sec
L31 = 20 - 65 m, H1/3 = 2.5 m, T1/3 = 10 sec
L32 = 65 = 265 m, H1/3 = 1.5 m, T1/3 = 10 sec

iii. Installation depth

East seawall

L21, L22 = 0 - 200 m, -0.6 m
L23 = 200 - 235 m, -0.6 m

Breakwater

L30-L32 = 0 - 265 m, -0.6 m

iv. Foundation

Both the east seawall and the breakwater are on a stable foundation of coral reef.

c) Structural design

The east seawall will be restored by a rubble slope type as the same as the previous structure for the distance of 200 m. For 35 m end section at the corner of the Shed No. 3 which is to be reinforced, the structure will be a gravity type with a parapet erected by in-situ concrete on the rubble mound and its front slope will be covered with armor stones.

The crown height of the seawall will be as follows.

i. The section which is to be restored to the original section shall meet the condition that substantial part of the waves will not overtop the seawall in consideration that the wave height is as low as 0.6 ~ 0.8 m and the area behind is to be paved under the ADB Project.

0.8 x H1/3 above the design HWL = +3.0 ~ +3.2 m.

ii. The section which is to be reinforced shall meet the condition that overtopping of the waves will be prevented as much as possible in view of the fact that it will not be sheltered by the breakwater and that there are buildings immediately behind it:

1.0 x H1/3 above the design high water level for the crown height of the armor stones = +3.9 m; crown height of the parapet = +4.40 by allowing for 0.5 m allowance.

The required weight of armor stones is calculated as 0.5 t for the section to be restored and about 1.0 ton for the section to be reinforced. As stones of this size are locally available, armor concrete blocks are not used.

There are different types of breakwater; a rubble slope breakwater and a composite breakwater combining rubble stones and concrete blocks. The rubble slope breakwater has been selected for this plan because it requires less volume of concrete and can be constructed in a short period of time. The crown height of the breakwater is determined as follow.

i) Since construction of the breakwater is performed from the land by an end-on system, the height of rubble mound should be at least 1.5 m high above the sea level.

ii) The breakwater crown height is level of the rubble mound plus the thickness of armour layer; for the section of 65 m from the breakwater head protected with three layers of armor concrete blocks, it is +4.2, and for the remaining section of 200 m to be protected with two layers of armor stones, it is +3.7 m.

iii) When these crown heights are adopted, the height above the design water level will be (0.6 - 0.7) x H1/3 for the 65 m section including the breakwater head, and 0.8 x H1/3 for the 200 m section in the trunk portion. Even when the design waves take place, influences of the overtopping and transmitting waves to the seawall are almost negligible.

The required weight of armor stones are calculated at 3.5 - 7.5 tons for the 65 m section and 1 ton for the 200 m section of the trunk portion. As the maximum weight of stones locally available is 2 tons, only the 200 m section will be covered with armor stones. For the 65 m section, 1.5 to 2 ton concrete blocks are required, however by considering larger blocks required for the breakwater head, 4 ton concrete blocks will be used for the 65 m distance.

3) Pilot boat and work boat

a) Restoration

The fittings and outboard engine for the damaged boats will be repaired. The items for repair are listed below.

i. Hull (Ship #596)

Repair of dents on the hull L/S

ii. Fittings (Ships #596 and 598)

Remote control panel for the outboard engine	Two sets
Battery and electric wiring	Two sets
Window screen with wiper and circular cover	Two sets
Small mast with red/white lights	Two sets
Ladder for pilot and partition column	Two sets
Driver and passenger seats	Two sets

iii. Outboard engine (Yamaha 175ps)

Fuel supply pipe	One set
Actuator	One set
Ignition plug	One set
Top cover	One set

iv. Tools

Mechanical tools	One set
Electric tools	One set

b) Specification for repair

The hull is made of aluminum and the repair of damaged parts can be done at a local shipyard of fishing boats. The boat will therefore be taken to the shipyard for repair.

Major portions of the fittings are to be purchased from Savage Pty, the Australian manufacturer of the boat, and shall be of either anti-corrosive aluminum or FRP. The electric tools and wiring will be of an outdoor type to be also purchased from Savage Pty, and mounted at site.

Parts for the outboard engine will be purchased from the Japanese manufacturer, and will be mounted at the repair shop of the Western Samoa Shipping Corporation.

4) Navigation aids

a) Restoration

The collapsed light tower in Apia Port shall be restored by installing a simple light at the previous location, because the new light tower will be installed at the end of the breakwater to be constructed under the Apia Port Development Project. The light buoy in Apia Fishing Port shall be restored by fitting the lamp which has been blown away. The scope of restoration work is as follows.

i. Light tower in Apia Port

Lantern	1 No.
Support (including ladder)	1 No.

ii. Light buoy in Apia fishing port

Lantern	1 No.
Battery	1 No.

b) Structural specification

For restoring a light tower, a solar type lantern will be mounted by erecting a steel pole on the existing concrete base. The light buoy shall be repaired with a lamp and battery, and piping and wiring concurrently replaced.

The specifications for the light tower and the light buoy are as follows.

i. Light tower

Luminous range	2 miles
Characteristics	Red, stationery

ii. Lamp for light buoy

Luminous range	5 miles
Characteristics	Red, flashing for 2 seconds

5) Marine Office

a) Restoration

As the existing marine office damaged by the cyclone "Ofa" is beyond repair, it shall be demolished and newly constructed. The location, layout plan and section of the new building are shown in Fig. 4-10(1) and Fig. 4-10(2).

The marine office shall have the following functions.

i. Control of incoming and outgoing ships

ii. Pilotage, mooring and tug boat operation

iii. Maintenance and repair of port facilities

The marine office will accommodate the following staff.

Harbour Master	1
Pilots	3
Electricians	2
Tug boat crew	6
Labourers	6
Clerk	1
Guardman	1
Total	20

Taking into consideration the facts that the present site of the office is liable to damage by future cyclones, that movement of ships in the port is not clearly checked and that is far from the mooring place of pilot and tug boats, the new office shall be constructed immediately behind the anchorage of small boats.

b) Design Conditions

i. Floor Area : 214.5 m^2

ii. Design Code Reference

- Structural design criteria refers to the Japanese standards while New Zealand standards will be used for the electrical work in view of maintenance convenience.

- Materials to be used

Concrete	: FC180 - 210 kg/cm^2
Reinforcing steel Bars	: SD30 (JIS) Yield Strength: 3,000 kg/cm^2
Steel	: SS41 (JIS) Yield Strength: 2,400 kg/cm^2
Timber	: laminated wood

- Design Loads

Seismic Load:

Zone C of the seismic zoning map of New Zealand standards

V = CISMR . Wt

Seismic Coefficient : C = 0.1

Importance Coefficient: I = 1.3 (public building)

Structural Material : M = 1.0 (RC)

Risk Factor : R = 1.1

Weight : Wt

V = 0.1 x 1.3 x 1 x 1.1 Wt = 0.15 Wt

Wind Load:

Reference Wind Velocity: V = 50 m/sec
Design Wind Velocity : Vs = S1 x S2 x V

S1: Topographical Correction Factor: 1.0

S2: Ground Surface, Building Height and Building Size Factor: 1.0

Vs: 1 x 1 x 50 = 50 m/sec

iii. Plumbing Design Standards

- Sanitary Units

The sanitary units used in the toilets will be selected pursuant to the Uniform Plumbing Code.

- Water Supply

Water supply to the building will be made by branching out from the nearby water main.

iv. Electricity Design Standards

Power supply of single phase 230V will be made to the building from the existing sub-station.

c) Structural Plan

Given the conditions of the local construction industry, the adoption of a rigid steel frame and reinforced concrete structure are judged the most appropriate to ensure a reasonable price and an accurate building structure. The use of such a structure will also lighten the building weight and will shorten the construction period.

The following points should be taken into consideration in designing the building.

i. A corrosion effect is high due to a briny air, because of proximity the sea.

ii. Local climate is of high temperature, heavy rainfall and high humidity throughout the year.

iii. Major building materials are to be imported.

iv. The construction period is limited.

Roof

Steel roofing materials will be used for easy maintenance and good workability. The insulation and durability factors of candidate materials will be considered at a design stage together with ventilation in a loft, use of heat insulation materials and adoption of anti-corrosion specifications.

Exterior Walls

Concrete blocks shall be used for exterior walls in preference of its durability and local availability. Concrete blocks shall be used with water tight paint finish to prevent damage from salty sea water permeation.

Interior Finish

A standard finish is with a mortar steel trowel for a concrete floor slab. A hardener finish will be applied to a floor to prevent abrasion. In an administrative office a vinyl floor tile shall be used. In rest rooms and a shower room, ceramic floor tiles are used.

A standard interior wall finish is a cement-plaster with paint while walls in the rest rooms and shower room are with a ceramic wall tile finish.

6) Sheds No. 1 and No. 3

a) Shed No. 1

The Shed No. 1 is damaged as shown in Fig. 4-11 with the roof materials blown away along the north and west sides and shall be repaired as below.

North side	85.8 x (1.9 + 6.1)	= 686.4 m^2
West side	24.4 x 6.1	= 148.8 m^2
Total		835.2 m^2

b) Shed No. 3

The Shed No.3 is damaged on north side roof and wall, three roll-up doors and support column as shown in Fig. 4-12 and shall be repaired as below.

Roof	(16.25 + 18.9) x 7.9	= 277.7 m^2
Wall	(5.4 + 7.4)/2 x 16.0 x 2	= 204.8 m^2
	24.5 x 5.4	= 132.3 m^2
	Total	614.8 m^2

Roll-up Door	3 Nos.
Column (for 31.4 m section)	L/S

7) Wooden fenders

a) Restoration

Wooden fenders shall be restored by replacing broken wooden piles and beams.

Scope of restoration shall be as follows.

i. The length to be restored is 90 m.

ii. Field survey has revealed two broken wooden piles and damaged beams for about 30 m section. As the fenders are currently in use for berthing, they are expected to be further damaged. Three piles shall be replaced and the beams for about 40 m section will be repaired.

b) Structure

The structure of fenders is wooden piles of about 30 cm in diameter driven at the intervals of 3 m. The pile heads are connected with the beams and fixed to the concrete slab of the main wharf with bolts and nuts.

Mulifnua Port

a) Navigation channel

i. Restoration

The silted channel and turning basin shall be dredged in order to restore the water depth and the channel width before the disaster.

The scope of restoration work shall be as follows.

- Channel

at -3.5 m depth	Distance	180 m
	Width	50 m
at -3.2 m depth	Distance	360 m
	Width	50 m

- Turning basin

at -3.2 m depth	Diameter	120 m

The channel in Mulifanua Port was dredged to accommodate the ferry boat "Queen Salamasina". Right after the dredging work, "Lady Samoa II"

was introduced by the Japanese Government's grant aid. The dimensions of these two ferries are almost the same as shown below, and the above mentioned scope of restoration work is sufficient for operation of "Lady Samoa II".

Ferry boat	Queen Salamasina	Lady Samoa II
LOA	39.60 m	43.43 m
Beam	10.35 m	11.50 m
Full draft	2.14 m	2.25 m

ii. Cross section of channel to be dredged

The dredging work is assumed to be implemented by a backhoe mounted on a barge and the depth and width of extra dredging are as follows.

- For both the channel and turning basin, the extra dredging depth shall be 30 cm.
- In the channel portion, the slope is of coral rock and the gradient is about 1:1, and no extra width will shall be allowed.
- The slope of turning basin is covered with coral sand or scoria, and the slope gradient for dredging shall be 1:2 and the extra dredging width shall be 4.0 m.

Dredged soil shall be dumped ashore, and refilled behind the south seawall of the ferry ramp which was washed away by the cyclone.

b) Ferry Ramp

i. Restoration

Since it is very difficult to restore the damaged ferry ramp to the previous section in the present place, a new ramp shall be constructed in front of the existing one.

ii. Design Condition

The design conditions of the ferry ramp are determined as follows through consideration of the dimensions of ships calling the port.

Planned depth	3.2 m
Design Ship	
LOA	45.0 m
Berthing energy	1.2 t.m
Tractive force	25.0 t
Soil condition	

As shown in Fig. 4-5, the subsurface soil conditions at the planned construction site are as follows.

Seabed ~ -3 m	: Loose sand N < 10
-3 ~ -5m	: Bed Rock

iii. Comparison of Alternative Design

Structural types for restoration of the ferry ramp can be selected from a gravity type as shown in Fig. 4-13(1) and a sheet pile wall as shown in Fig. 4-13(2). Both types are to be constructed in front of the existing ramp and are compared as follows.

o Gravity type

- Structure is very simple and construction period is short.
- Large crane is required handling concrete blocks.

o Sheet pile type

- Bed rocklies very shallow and stability of sheet pile is questionable especially in the section of the existing gravity type ramp.
- Most parts of the existing structure have to be removed in order to allow for driving work of rear wall and installation of tie rods.

In consideration of the above, a gravity type has been selected for the restoration work.

iv. Basic Design

The standard cross section of the ferry ramp for restoration is shown in Fig. 4-13(1). The faceline of the new ramp is set 5 m seawards from the present faceline for easier construction work. Concrete blocks are placed on 1.0 m thick rubble mound. The structure is as the same as the existing ramp for the section above -2.0 m.

c) -3.5 m Wharf

The repair works to the -3.5 m wharf are summarized as follows.

- Construction of retaining wall along the back of the concrete deck.
- Backfilling and compaction work

- Placing concrete slab
- Repair work to the oil tank

The surcharge to the wharf shall not include a heavy truck load assuming the wharf will be used by such small boats as "Alia".

d) Seawall

i. Restoration

The damaged north and south seawalls shall be repaired to the previous section.

The scope of restoration work will be as follows.

- North seawall

Revetment	Length 100 m (mainly on the side of the terminal area)
Road	Width 3.0 m, length 50 m

- South seawall — Length 50 m (mainly on the side of the ferry basin)

ii. Design conditions

Design conditions for the seawalls are determined according to the natural conditions discussed in Section 4.2 of this chapter.

- Water level

HHWL	+2.4 m
HWL	+1.0 m
LWL	+0.0 m

- Waves

North seawall	H1/3 = 0.9 m, T1/3 = 10 sec
South seawall	H1/3 = 0.9 m, T1/3 = 10 sec

- Installation depth

  North seawall +0.0 m
  South seawall -2.0 m

- Foundation

  The foundation is of coral reef for both north and south seawalls.

iii. Structural design

For both north and south seawalls, a rubble slope type shall be adopted.

The crown heights of the seawalls are as follows.

- Drift wood pieces and coral rocks were washed over the area near the ferry terminal by the cyclone waves, but the building suffered hardly any significant damages. Therefore, the crown height is designed to a condition that a substantial part of the waves will be prevented from overtopping: 0.8 H1/3 above the design HHWL or +3.2 m.

- The south seawall is designed to prevent wave overtopping as much as possible and erosion of backfill materials: 1.0 H1/3 above the design HHWL or +3.3 m.

  The required weight of armor stones of the revetment is calculated at 0.5 ton, and such stones are available locally.

e) Navigation aids

All the navigation aids shall be restored to the previous conditions.

i. Beacon

- Front beacon : tower and lantern
- Rear beacon : lantern
- Lantern : luminous range, 6 miles solar battery powered

ii. Marking Posts 11 Nos.

The structure is illustrated in Fig. 4-16.

(3) Salelologa Port

All the navigation aids shall be restored to the previous conditions.

1) Front and rear beacons : lantern, luminous range 6 miles, solar battery powered

2 Marking light : lantern, luminous range, 2 miles, solar battery powered

3) Marking posts 6 Nos.

The structure is illustrated in Fig. 4-16.

(4) Navigation Aids

1) Aleipata Lighthouse

Lantern: luminous range 20 miles, solar battery powered
Door : renewal

2) Apolima Lighthouse

Lantern: luminous range, 20 miles, solar battery powered
Door : to be attached

3) Malua Reef Lighthouse

Lantern: luminous range, 10 miles, solar battery powered
Ladder : to be attached

(5) Design Drawings

The design drawings of restoration works in Apia, Mulifanua and Salelologa Ports are listed as below.

Fig. 4-6	Layout Plan of Restoration Works, Apia Port
Fig. 4-7	Standard Cross-section of Restoration Work, Causeway, Apia Port
Fig. 4-8	Standard Cross-section of Restoration Work, Seawall, Apia Port
Fig. 4-9 (1)	Standard Cross-section of Restoration Work, Breakwater (Alternative Plan), Apia Port
Fig. 4-9 (2)	Standard Cross-section of Restoration Work, Breakwater and Seawall (Original Plan), Apia Port
Fig. 4-10 (1)	Layout Plan of New Marine Office, Apia Port
Fig. 4-10 (2)	Side View of New Marine Office, Apia Port
Fig. 4-10 (3)	Layout of the Existing Marine Office, Apia Port
Fig. 4-11	Shed No. 1, Apia Port (Floor Plan)
Fig. 4-12	Shed No. 3, Apia Port (Floor Plan)
Fig. 4-13 (1)	Standard Cross-section of Restoration Work, Ferry Ramp, Mulifanua Port
Fig. 4-13 (2)	Standard Cross-section of the Existing Ferry Ramp, Mulifanua Port
Fig. 4-14	Standard Cross-section of Restoration Work, -3.5 m Wharf, Mulifanua Port
Fig. 4-15	Standard Cross-section of Restoration Work, Seawall, Mulifanua Port
Fig. 4-16	Sketch of Navigation Aids.

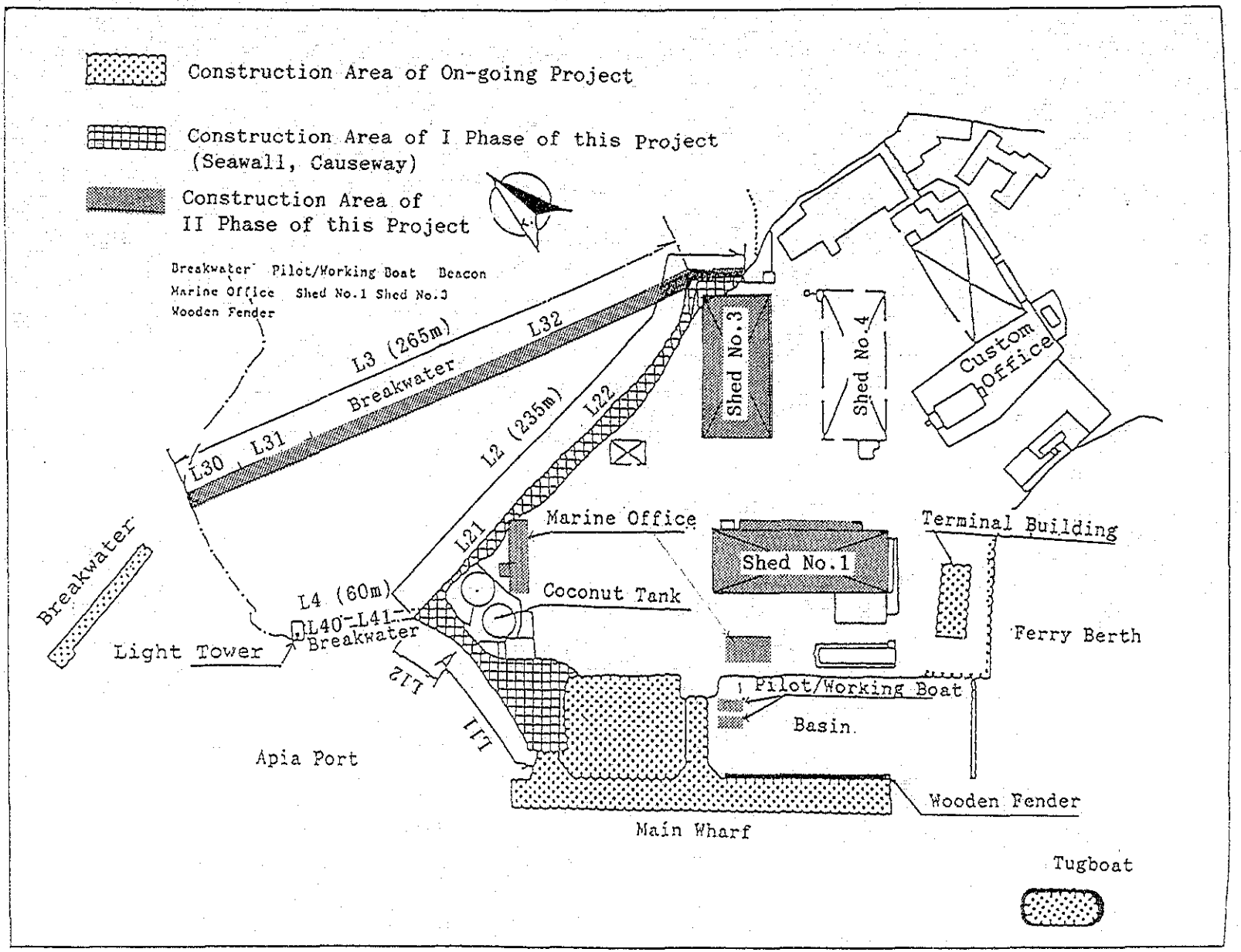


Fig. 4-6 Layout Plan of Restoration Works, Apia Port

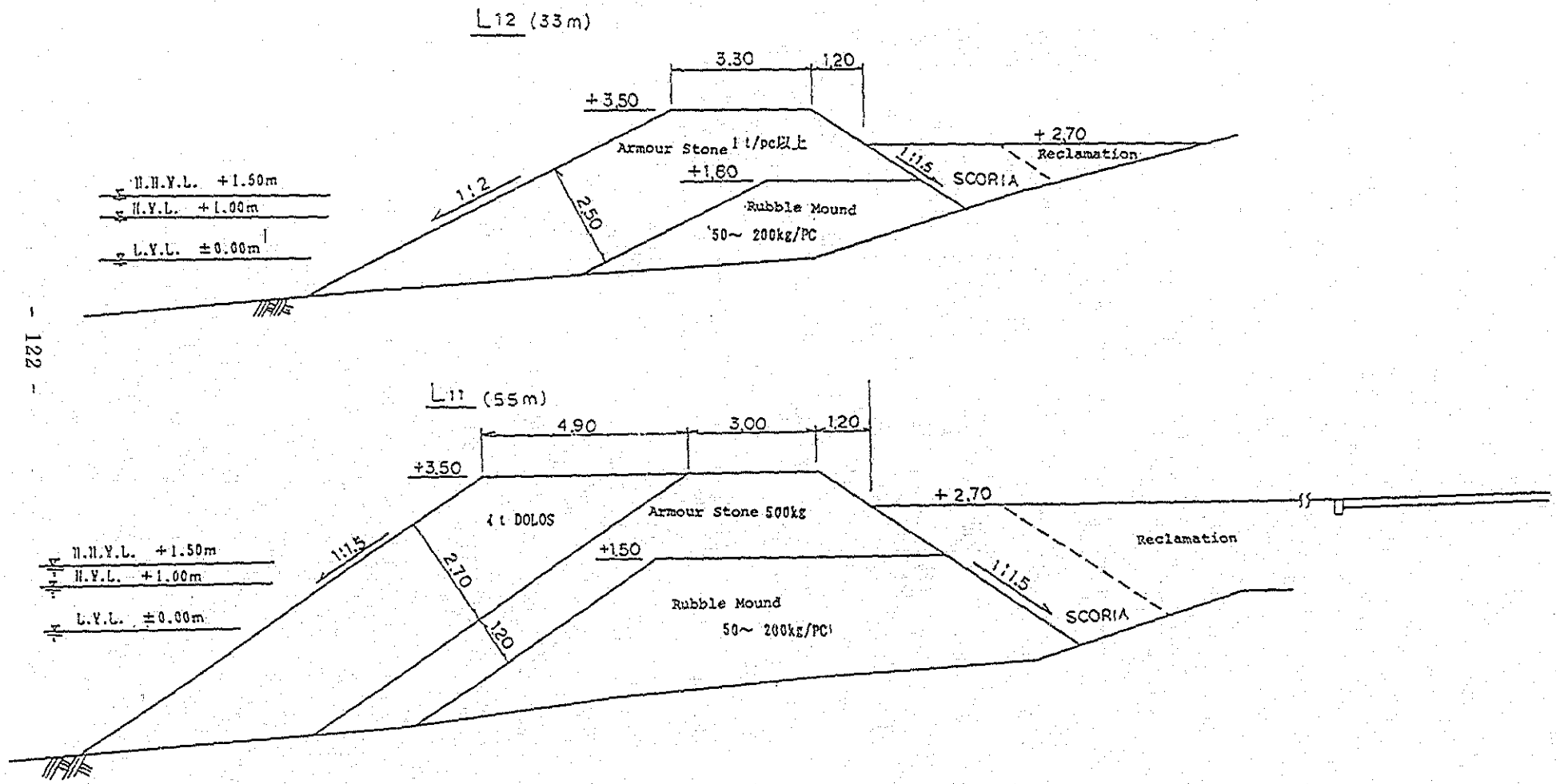


Fig. 4-7 Standard Cross-Section of Restoration Works, Causeway, Apia Port

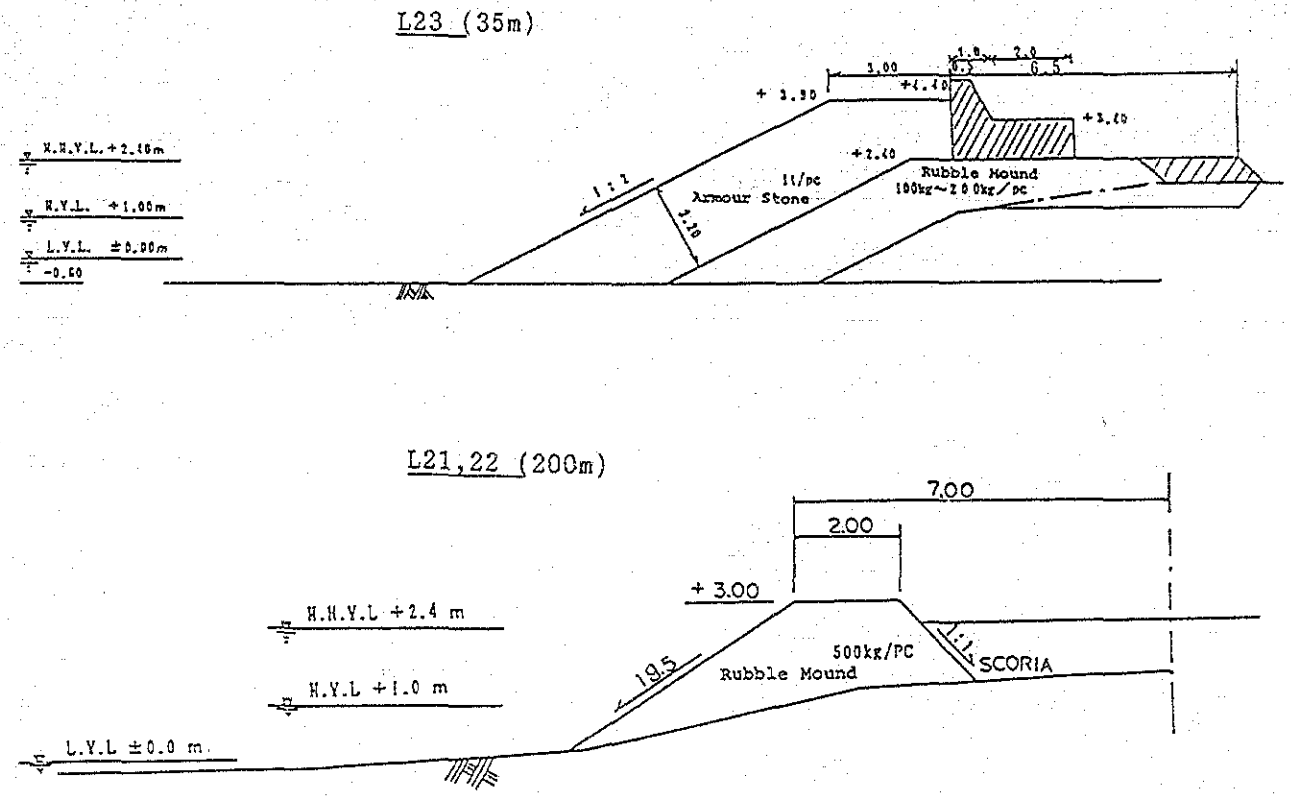


Fig. 4-8 Standard Cross-Section of Restoration Works, Seawall, Apia Port

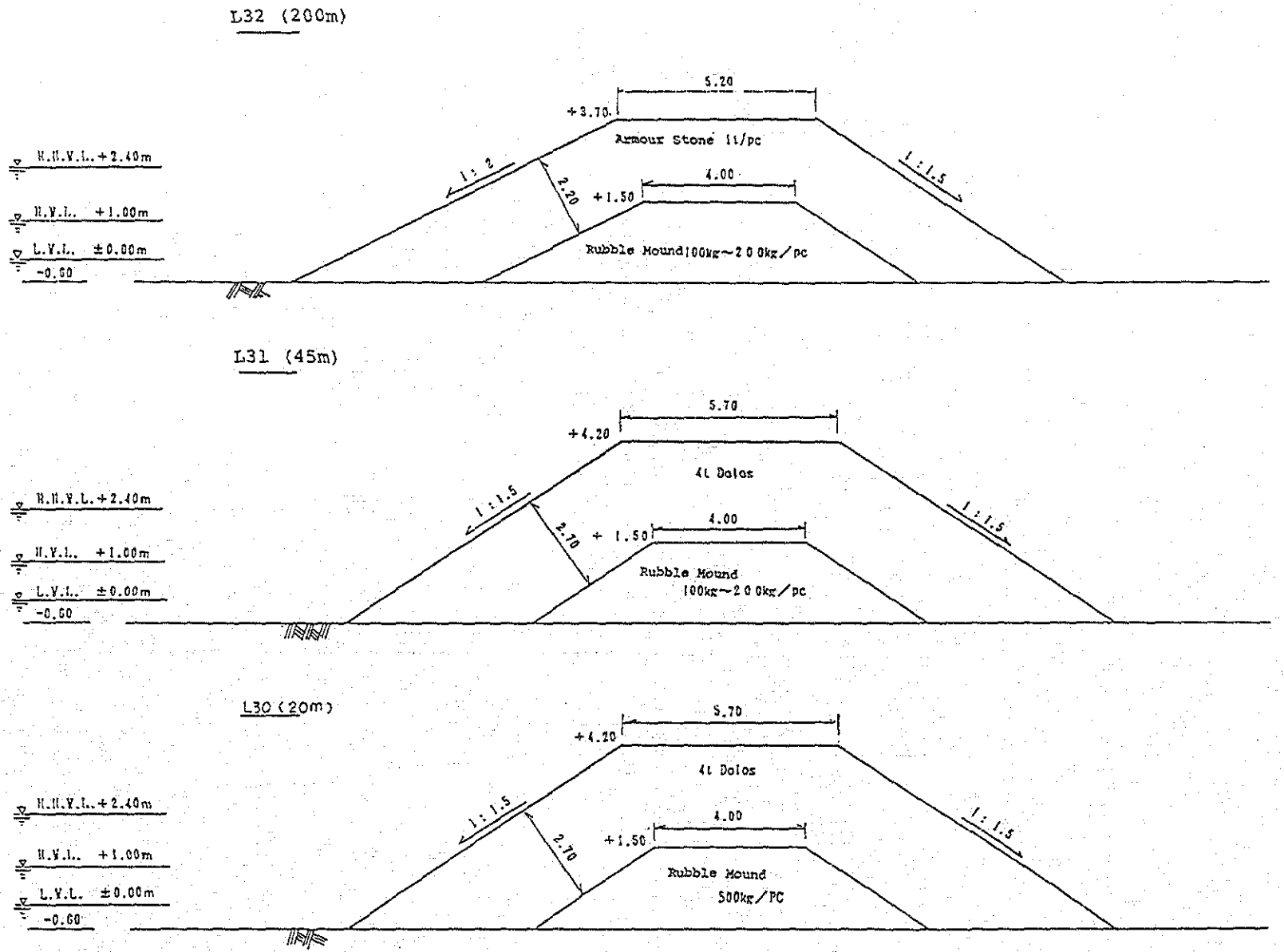


Fig. 4-9(1) Standard Cross-Section of Restoration Works, Breakwater (Alternative Plan), Apia Port

Fig. 4-9(2) Standard cross-Section of Restoration Works,
Breakwater and Seawall (Original Plan), Apia Port

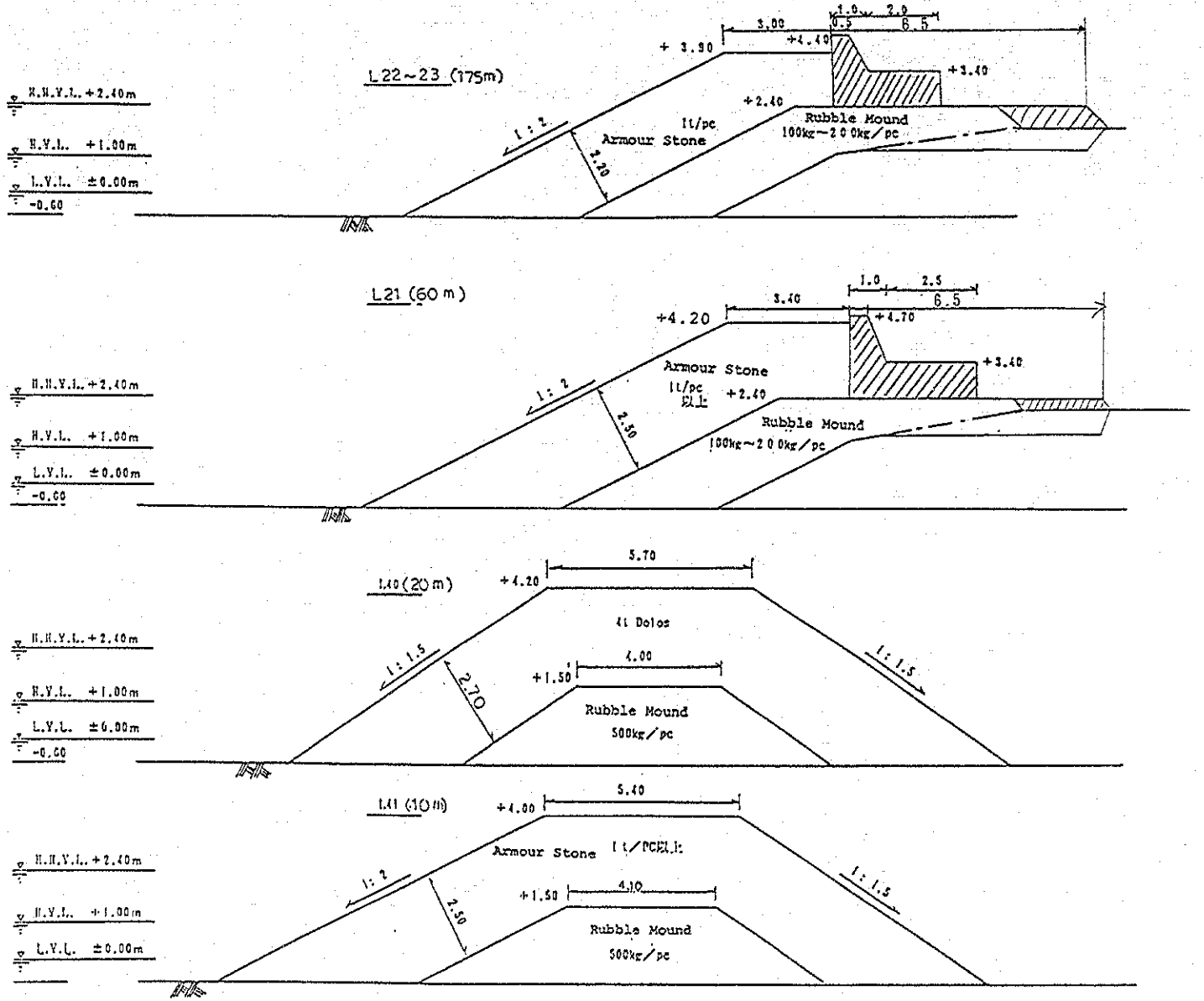
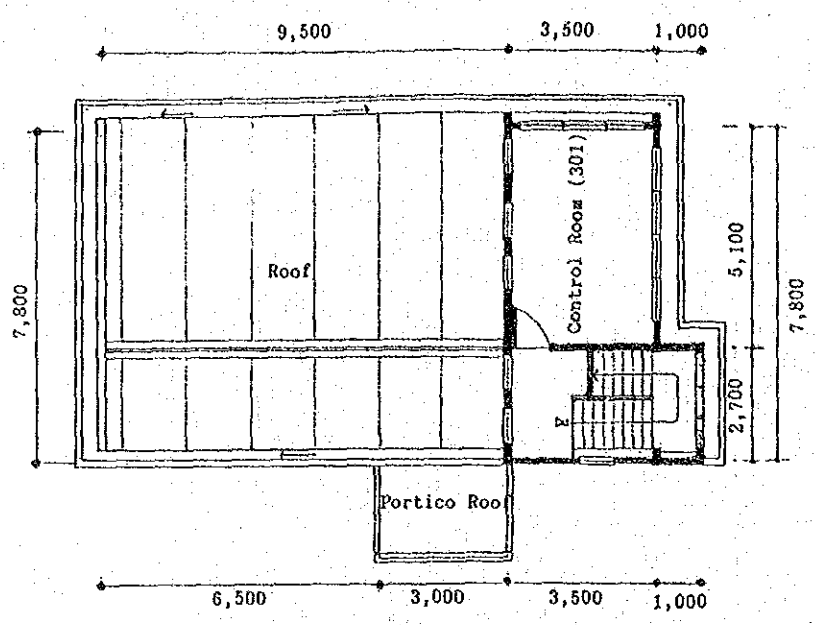
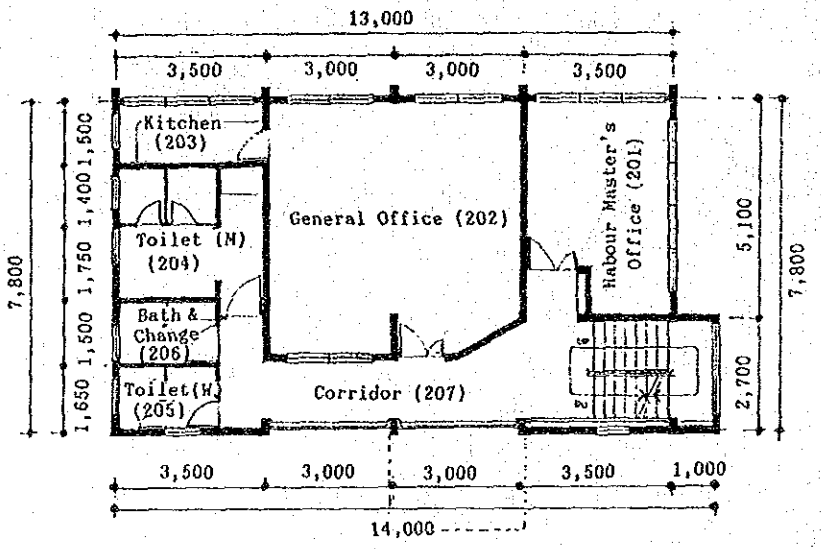


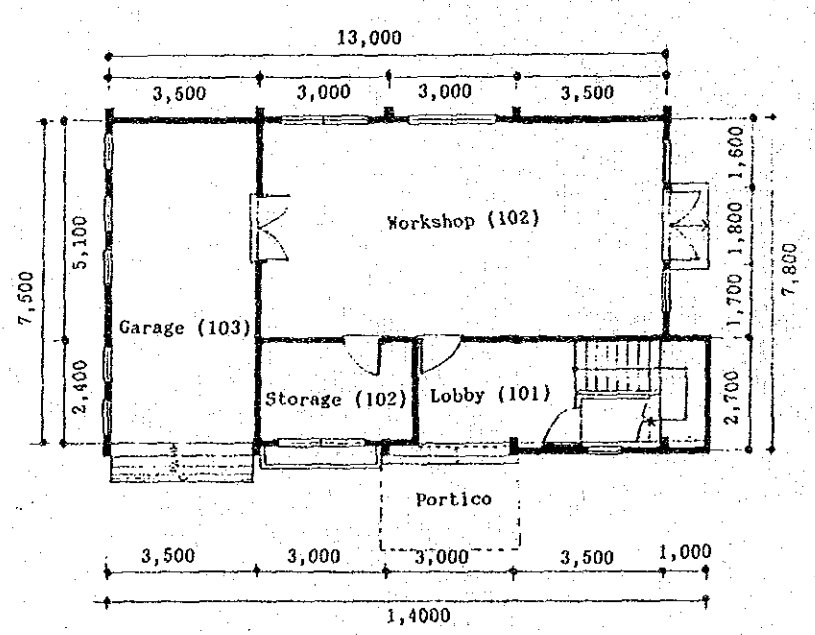
Fig. 4-10(1) Layout Plan of New Marine Office, Apia Port



Third Floor Plan



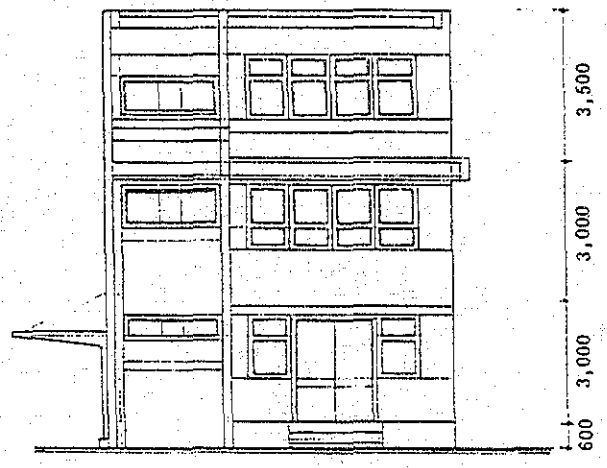
Second Floor Plan



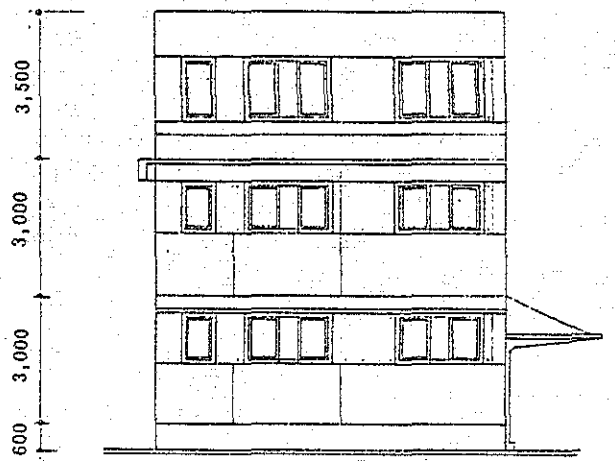
First Floor Plan

Scale 1: 100
Unit : mm

Fig. 4-10(2) Side View of New Marine Office, Apia Port

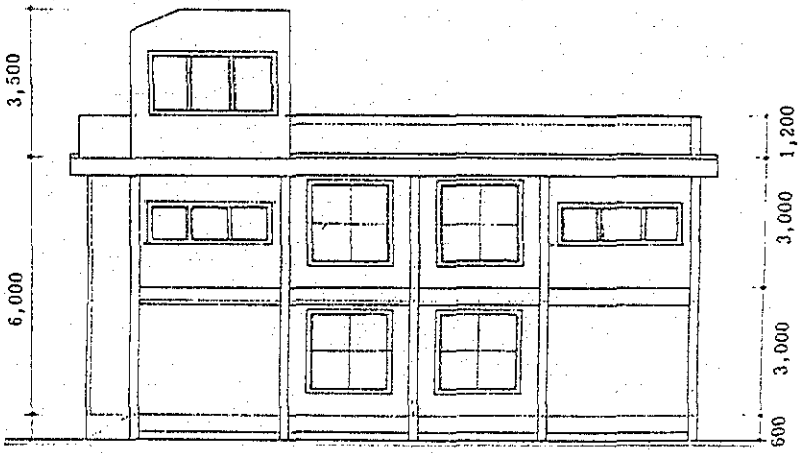


North Elevation



South Elevation

West Elevation



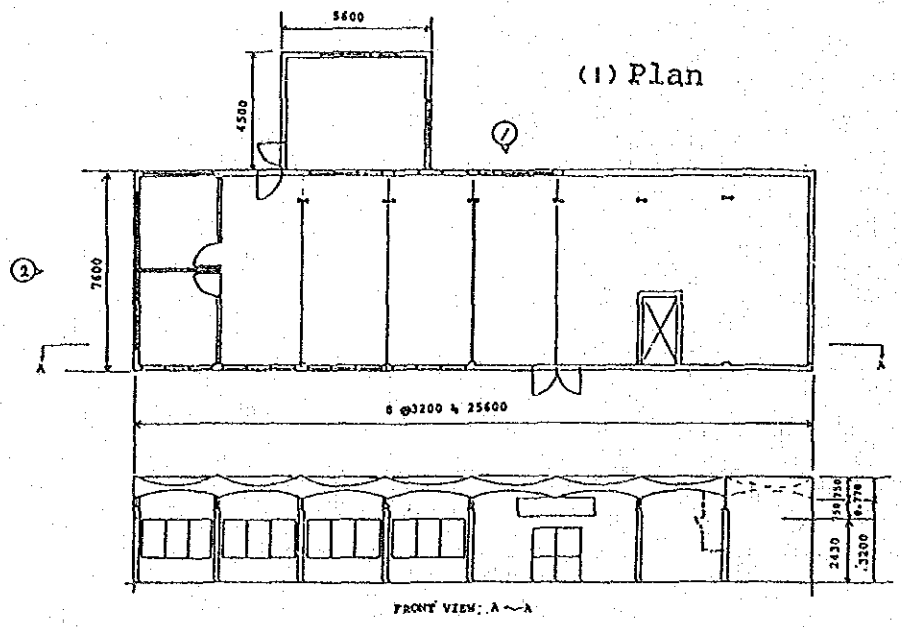
East Elevation

Scale 1: 100

Unit : mm

MARINE OFFICE (EXISTING)

UNIT:mm



MARINE OFFICE (EXISTING)

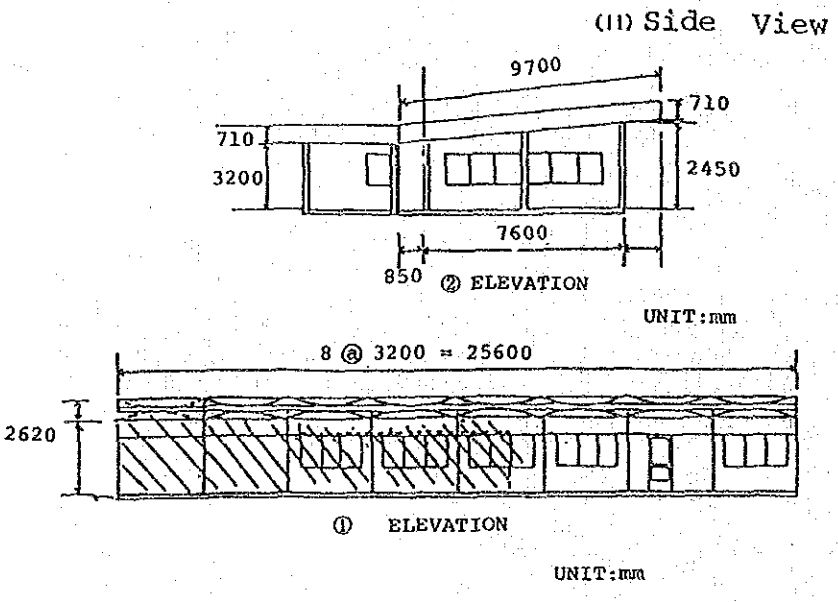
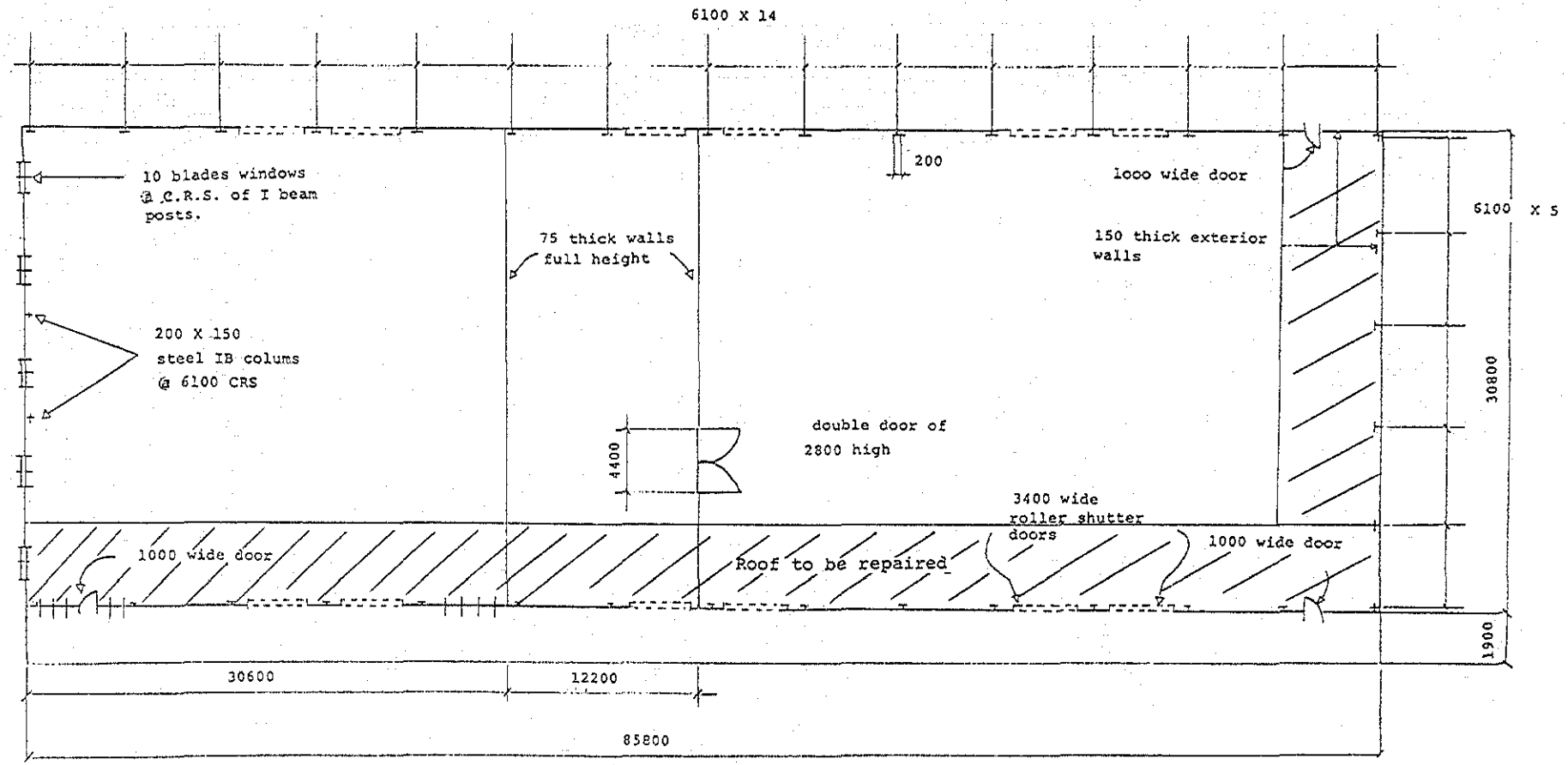


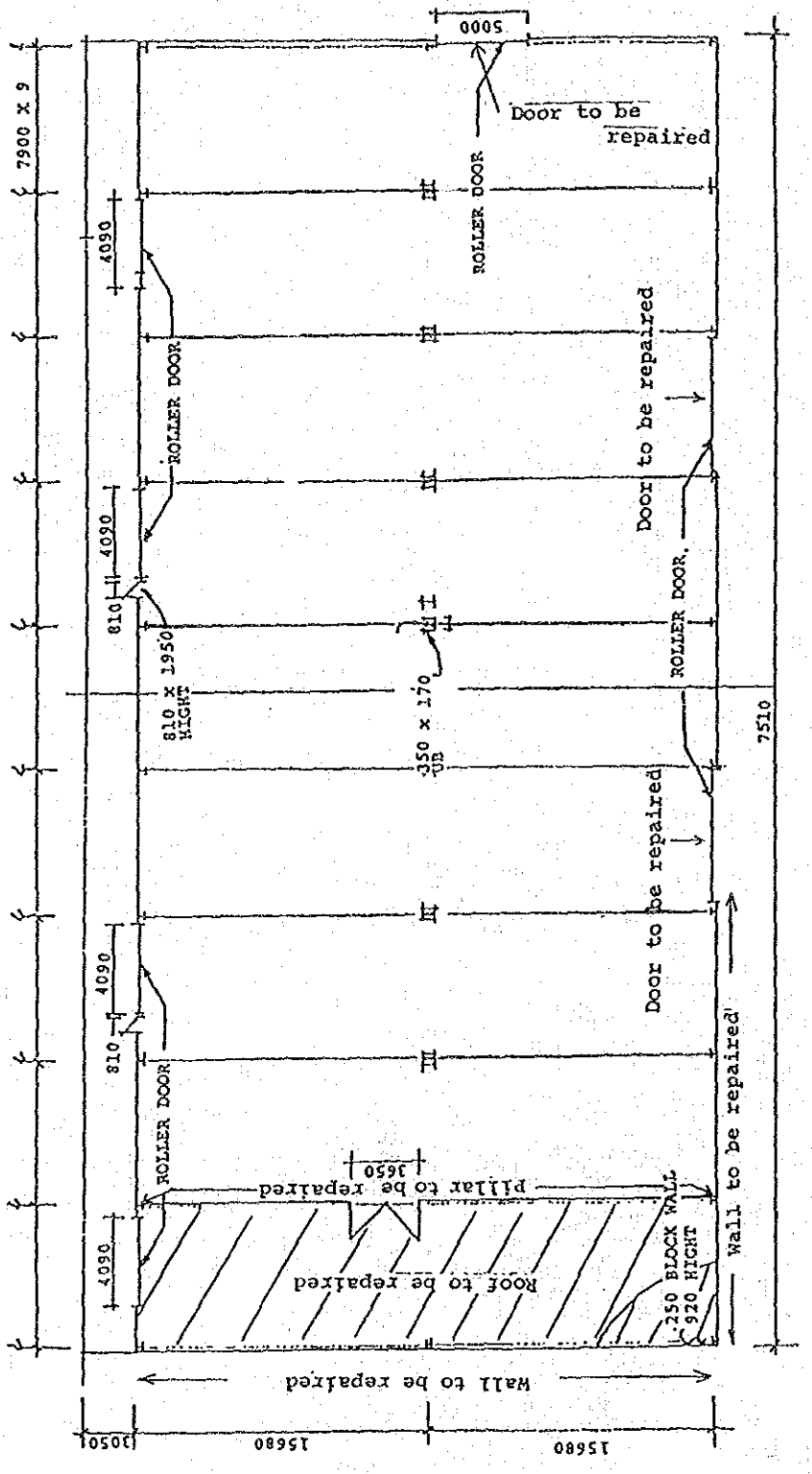
Fig. 4-10(3) Layout of the Existing Marine Office, Apia Port

Fig. 4-11 Shed No.1, Apia Port (Floor Plan)



FLOOR PLAN

Unit : mm



FLOOR PLAN

Unit : mm

Fig. 4-12 Shed No.3, Apia Port (Floor Plan)

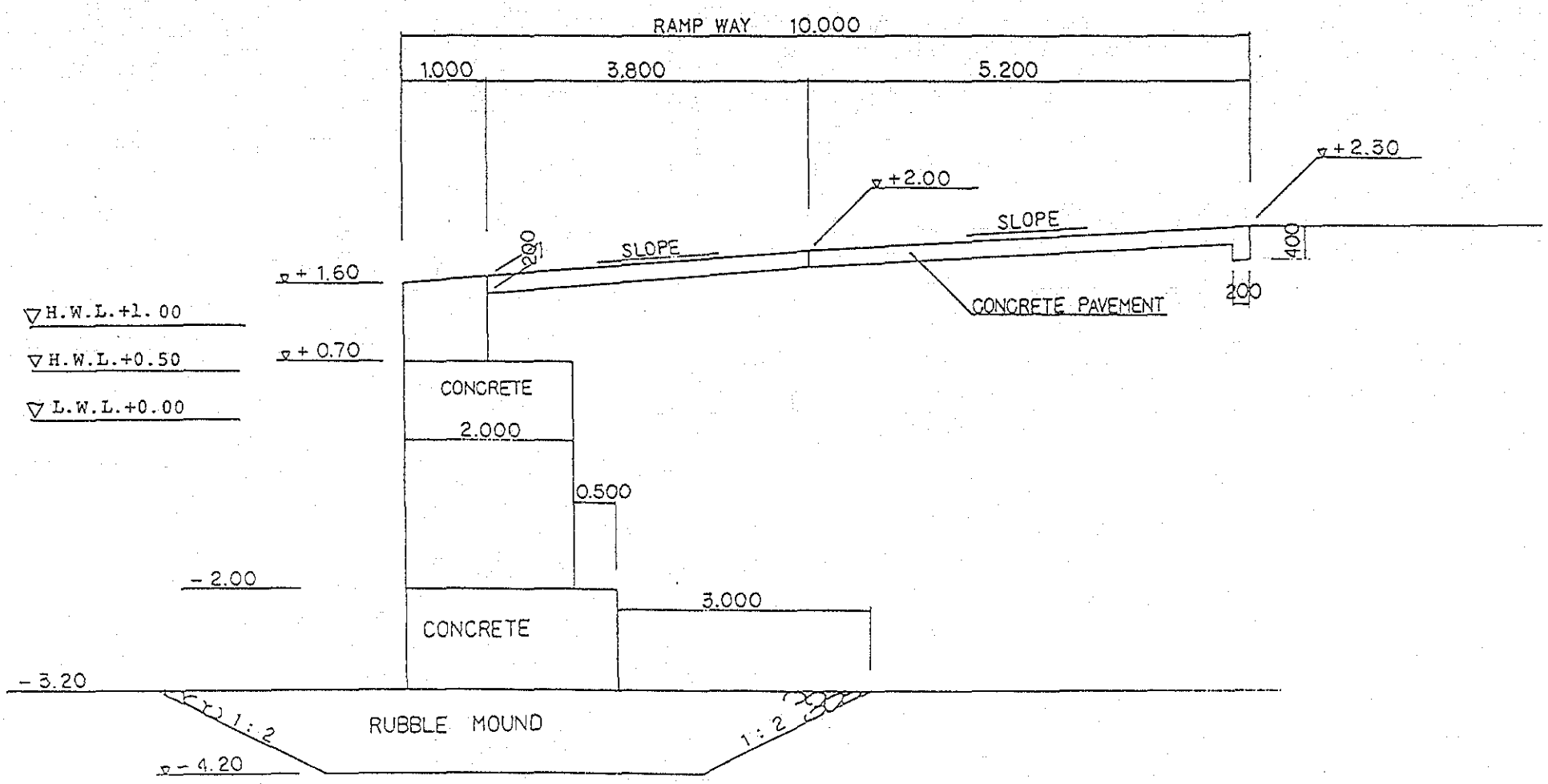


Fig. 4-13(1) Standard Cross-Section of Restoration Works, Ferry Ramp, Mulifanua Port

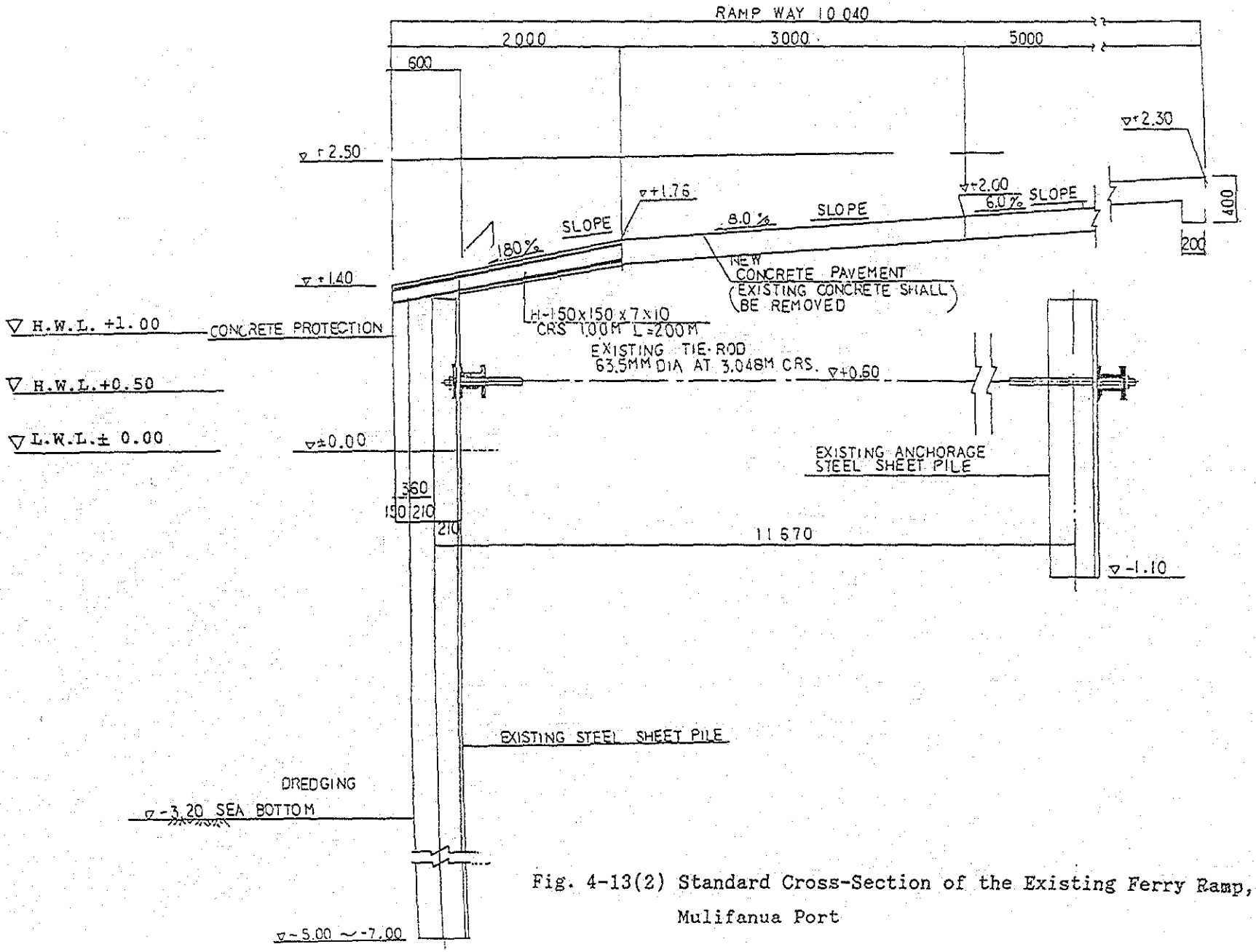


Fig. 4-13(2) Standard Cross-Section of the Existing Ferry Ramp, Mulifanua Port

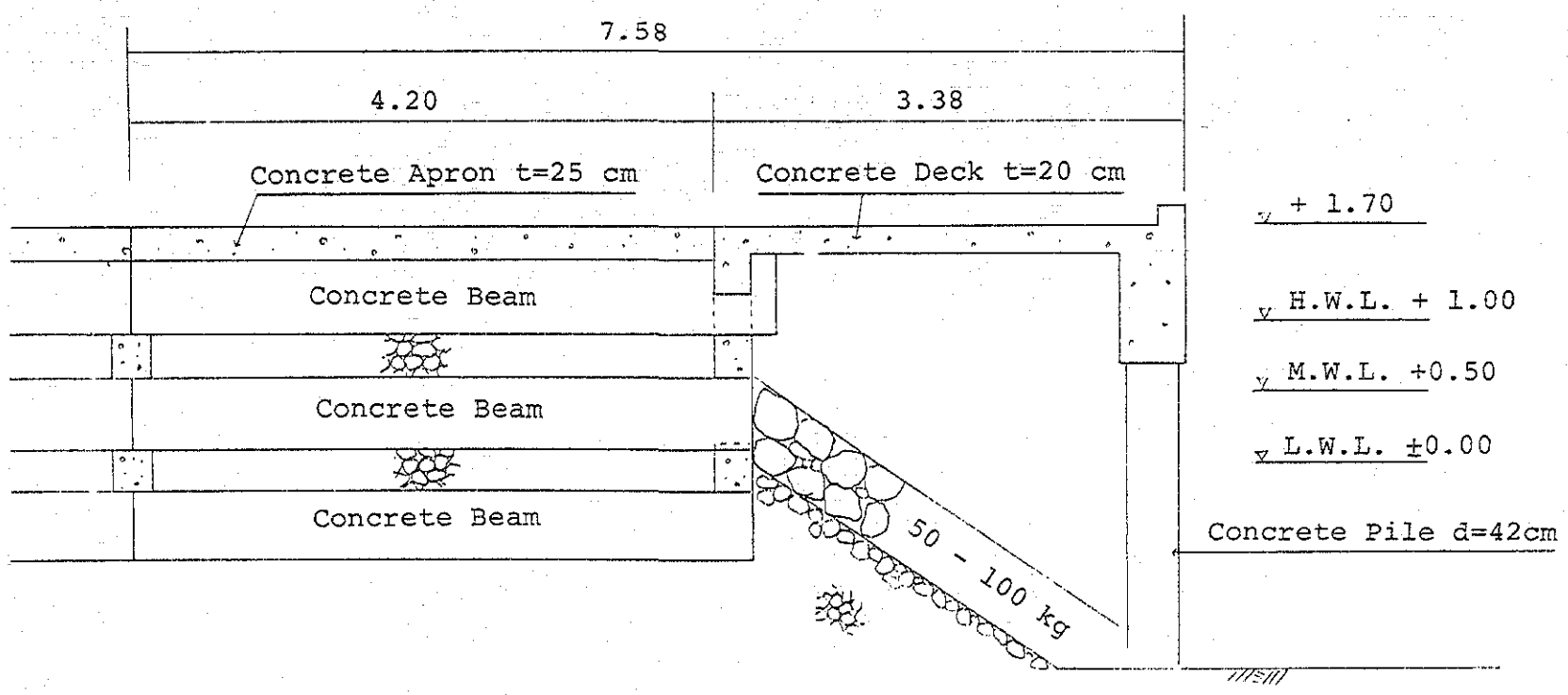
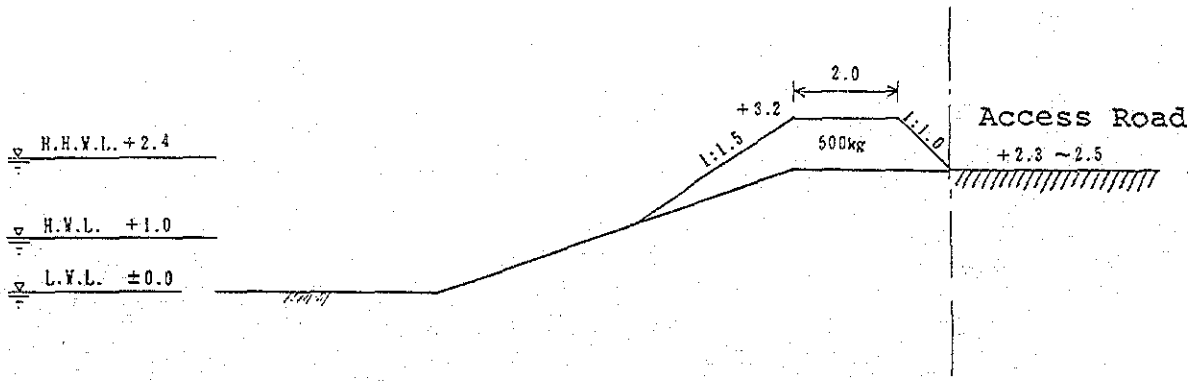


Fig. 4-14 Standard Cross-section of Restoration Works, -3.5 m Wharf, Mulifanua Port

1. North Seawall



2. South Seawall

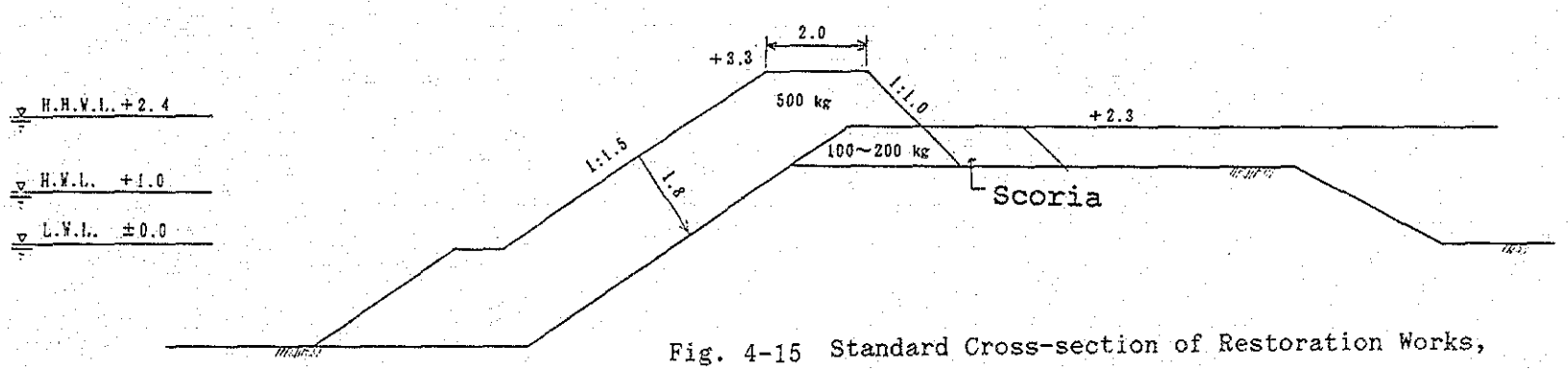
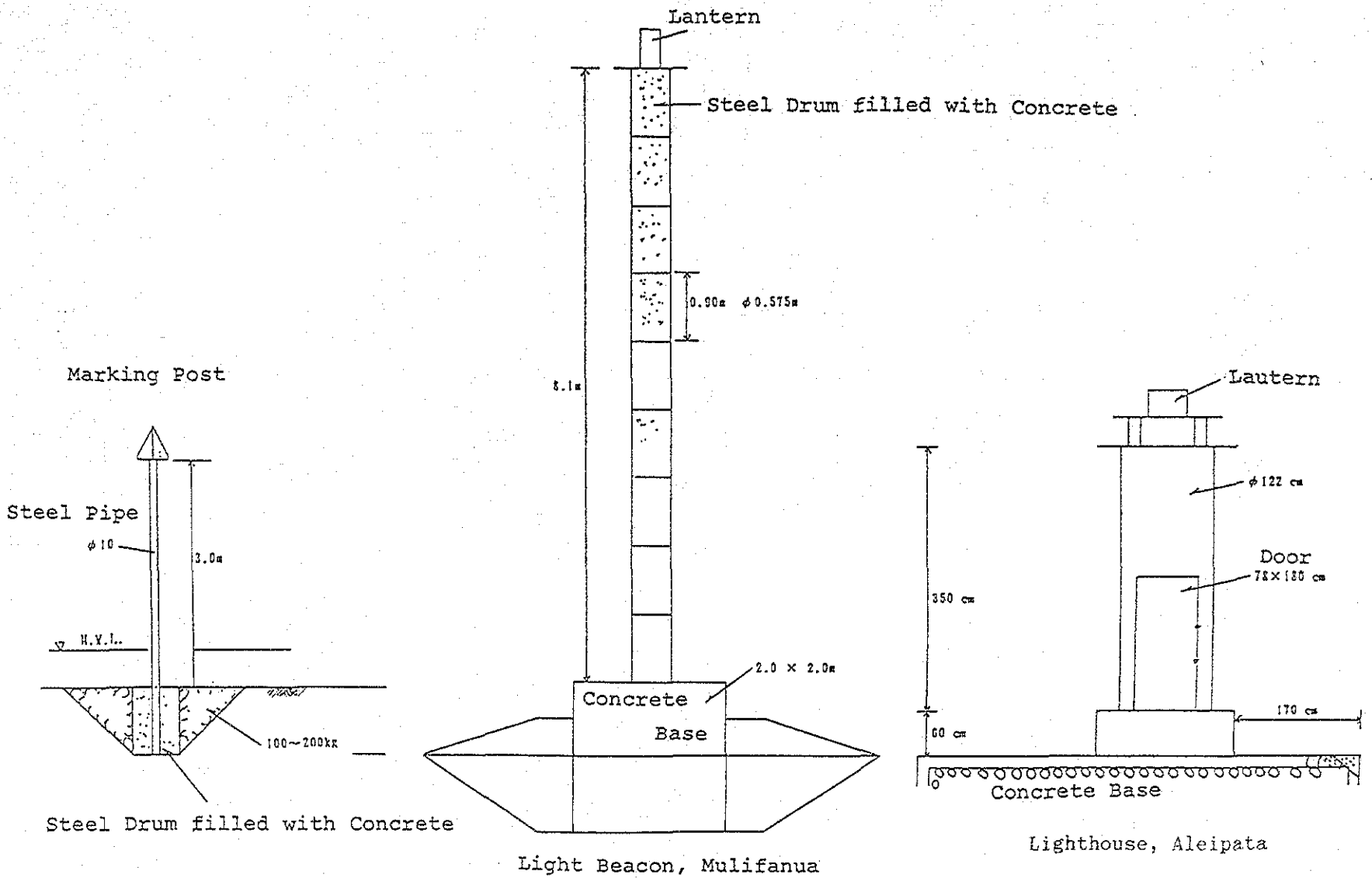


Fig. 4-15 Standard Cross-section of Restoration Works, Seawall, Mulifanua port

Fig. 4-16 Sketch of Navigation Aids



Light Beacon, Mulifanua

Lighthouse, Aleipata

4.3.2 Design of Quarry Plant

(1) Capacities of Required Equipment

The capacities of a crusher and its ancillary equipment can be calculated in terms of the maximum hourly production volume of the quarry. The functions and capacities of the ancillary equipment are examined in detail below.

a) Crusher

- For crushing raw rock.
- For screening crushed stone.

Required Production Capacity of Crusher

A jaw crusher and a cone type crusher are used in the most cases as a primary crusher and a secondary crusher respectively and these types of crushers have been selected in this project.

The production capacities of a crusher by type and stone size are shown in the following table.

Production Capacity of Crusher

(Unit: t/h)

Stone Diameter (mm)	Rated Capacity of Production		
	100 t/h	75 t/h	50 t/h
38 - 21	30.5	23.0	11.9
21 - 18	33.8	24.6	15.6
18 - 10	12.3	9.3	9.2
10 - 7	8.7	6.7	6.7
7 - 5	5.1	3.9	2.2
5 - 0	9.6	7.5	4.4

Based on the annual demand of crushed stone given in 2.3.4, the required working hours by each stone size and machine type have been calculated as shown in the following tables, necessitating introduction of a 100 t/h class crusher.

Required Annual Operation Hours (1992)

Crushed Stone Diameter / Stone Diameter (mm)	40-	20-	20	10	7-	Various Sizes	Total	
Crushed Stone Volume, Plant Capacity								
Annual Volume Required (m^3)	17,900	11,100	6,900	11,700	2,800	1,800	(m^3) 52,100	
Annual Tonnage Required(tons)	35,800	22,200	13,800	23,400	5,600	3,600	(tons) 104,400	Real Production Capacity
Required Operation Hours of 100 ton/hr Class Crusher	360	320	410	700	(Note 1) (380)	40	(hrs) 1,830	(t/h) 57

Note 1: Stone with a diameter of less than 7 mm is produced as a by-product of other sizes.

Assuming a 10% reduction of the annual operation hours of the quarry plant for repair and maintenance, the resulting actual operation hours are calculated at 1,728 hrs/year as below.

8 hrs/day x 5 days/wk x 48 wks/yr x 0.9 = 1,728 hrs/yr

Comparison of this figure with the required annual operation hours leads to a selection of a crusher of production capacity of 100 t/h.

In 1992 when the required operation hours will be 1,830, the volume of crushed stone produced in the standard working hours will not meet the estimated demand. Overtime work, of about 0.5 hours per day is required to solve this situation.

b) Bulldozer

- For removal, cutting and transportation of surface soil and weathered rock, unsuitable for raw material of crushed stone.
- For leveling of cutting bench, stock yard and access road.

A 35 - 50 ton class bulldozer is usually used for removal and cutting of the surface layer. As the rock in the Alafua quarry consists of hard basalt, a bulldozer of at least 35 ton class equipped with a rock ripper and soil scraper is required.

c) Drills

- For drilling holes to set explosives.

The height of the cutting bench in the Alafua quarry is set at 10 m. In order to supply 100 tons of raw rock in one hour (approx. 33 m^3, a specific gravity: 3.02), 2 drills are required as the maximum production volume of a single drill is estimated at 67.71 t/h. One drill can be expected to drill a hole about 10 m deep with a diameter of 63.5 mm in one hour. Given the hole intervals of 2.6 m along the bench and the distance between the hole and the bench slope of 2.2 m, 57.2 m^3 of stone can be produced per drilled hole /h.

2.6m x 2.2m x 10m = 57.2m^3 (172.7 tons)

The above hourly production volume of 172.7 tons has to be reduced to 67.71 t/h, assuming that a mixture rate of soft rock, etc. of 20%, a working efficiency factor of 0.7 and an actual working hour coefficient of 0.7 as calculated below.

172.7 x (1.0 - 0.2) x 0.7 x 0.7 = 67.71 t/h

d) Wheel Loaders for Raw Rock

- For transportation and loading of raw rock to dump trucks.

  A wheel loader of 15-20 t class is required to handle blasted rocks weighing 0.5 - 2.0 t per piece and a 15 t class wheel loader with about 2.5 m^3 bucket has been selected.

- For feeding raw rock into a primary crusher.

The wheel loader of the same capacity is required.

e) Dump Trucks

- For transportation of raw rock from the cutting bench to the primary crusher hopper.

  As an average distance between the primary crusher hopper and the cutting bench is about 1 km, one operation cycle by a dump truck will take 12 minutes for 12 t load, i.e. 3 minutes for traveling to the bench, 2 minutes for loading, 6 minutes for traveling to the crusher and 1 minute for unloading. The working rate is, therefore, 1 ton per minute. Given a working efficiency factor of 0.7 and an actual working hour coefficient of 0.8, the minimum number of dump trucks required is 3 as calculated below.

  12/12 x 0.7 x 0.8 = 0.56 (t/min/vehicle)

  hourly work volume: 33.6 (t/h/vehicle)

  100 (t/h)/33.6 (t/h) vehicle = 2.9 (vehicles)

  One more dump truck is required to allow for repair and regular maintenance to the above three trucks. The loading bed shall be of a 6 mm thick steel plate to load heavy raw rocks.

f) Wheel Loader for Crushed Stone

- For loading crushed stone onto purchasers' dump trucks.
- For transportation and sorting of crushed stone in a stockyard.

A wheel loader with a bucket capacity of 1.7 m^3 is required on the assumption of 100 t of crushed stone to be loaded per hour, working efficiency factor of 0.8, an actual working hour coefficient of 0.3 and a loading cycle of 30 seconds as calculated below.

$50\ m^3 / (120 \times 0.8 \times 0.3) = 1.7\ m^3$

A low actual working hour coefficient of 0.3, is used for a crushed stone loading operation to reflect an irregular arrival of purchasers' dump trucks. In addition to the loading operation, the loader will also be engaged in sorting and transportation of stone at the stock yard.

g) Pick-up Trucks

- For transportation of dynamite, repair parts and consumables, etc.

These trucks are required for the above purposes in and outside the quarry site.

h) Station Wagon

- For general administration purposes.

This vehicle is required for general administration purposes.

(2) Layout Plan of the Quarry

The layout plans of the quarry and the crusher are shown in Fig.4-17 ~ 4-19. The access road and the in-yard roads require improvement, including reinforcement of a bridge and

expansion of the road width, to secure smooth and safe operation of the quarry.

4.4 Implementation Plan

4.4.1 Implementation Policies

(1) Implementation Policies

This project will be carried out under the scope of the Japanese Grant Aid System. After approval of the project by the Government of Japan and the Government of Western Samoa, an Exchange of Notes(E/N) will be taken place between both governments and the project plan will be officially put into effect. Then, a Japanese consultant, which shall be appointed by the Government of Western Samoa will start the detailed design work of facilities and equipment. After preparation of tender documents by the consultant, Japanese contractors shall be selected by tender and then the construction work will commence. Quarry plant will be provided by a Japanese trading company which shall be selected by another tender.

The construction period is expected to be 19.5 months taking into consideration the scope of the project and site conditions. The length of the construction period will be governed by the causeway of Apia Port and the channel dredging in Mulifanua Port.

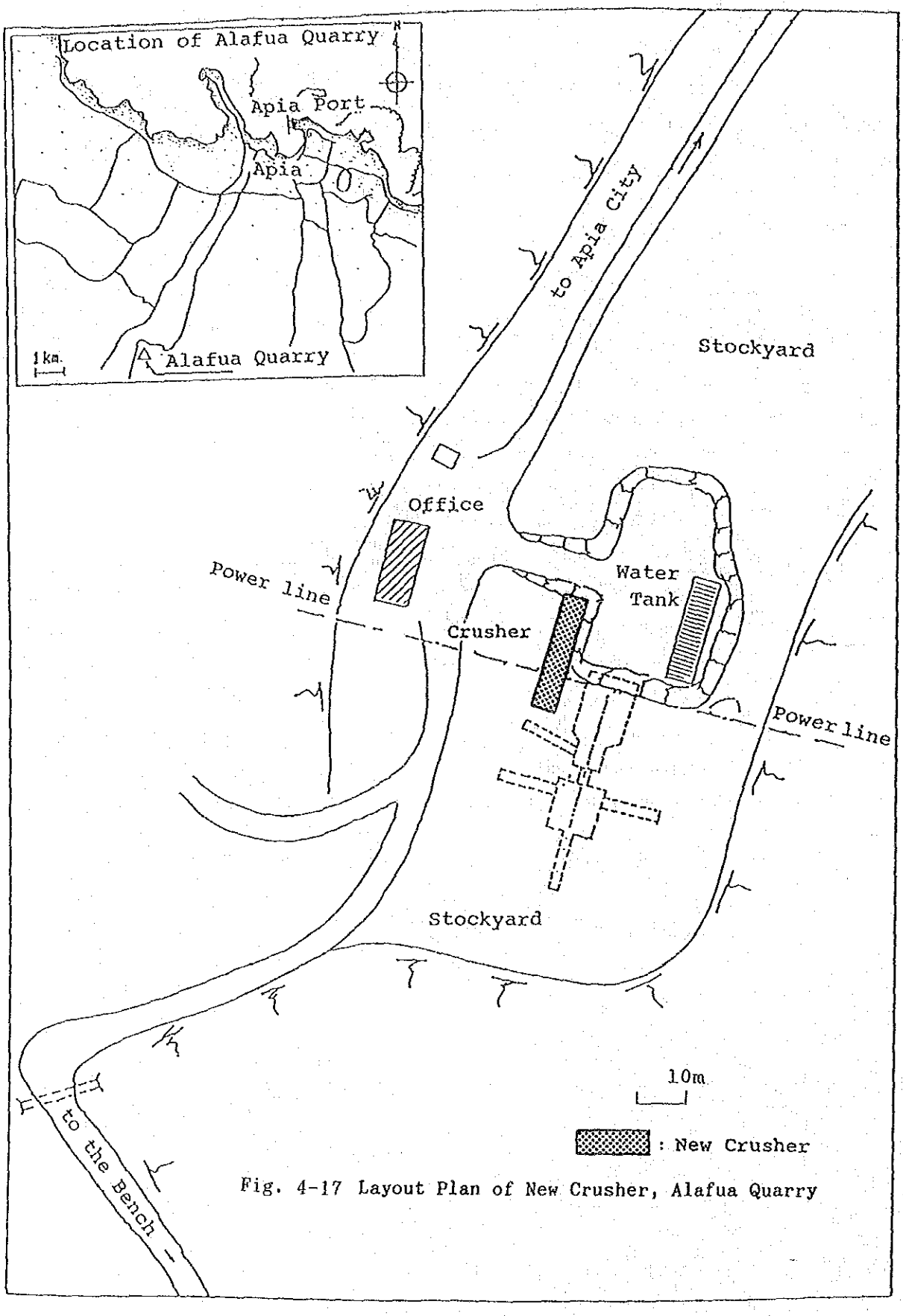


Fig. 4-17 Layout Plan of New Crusher, Alafua Quarry

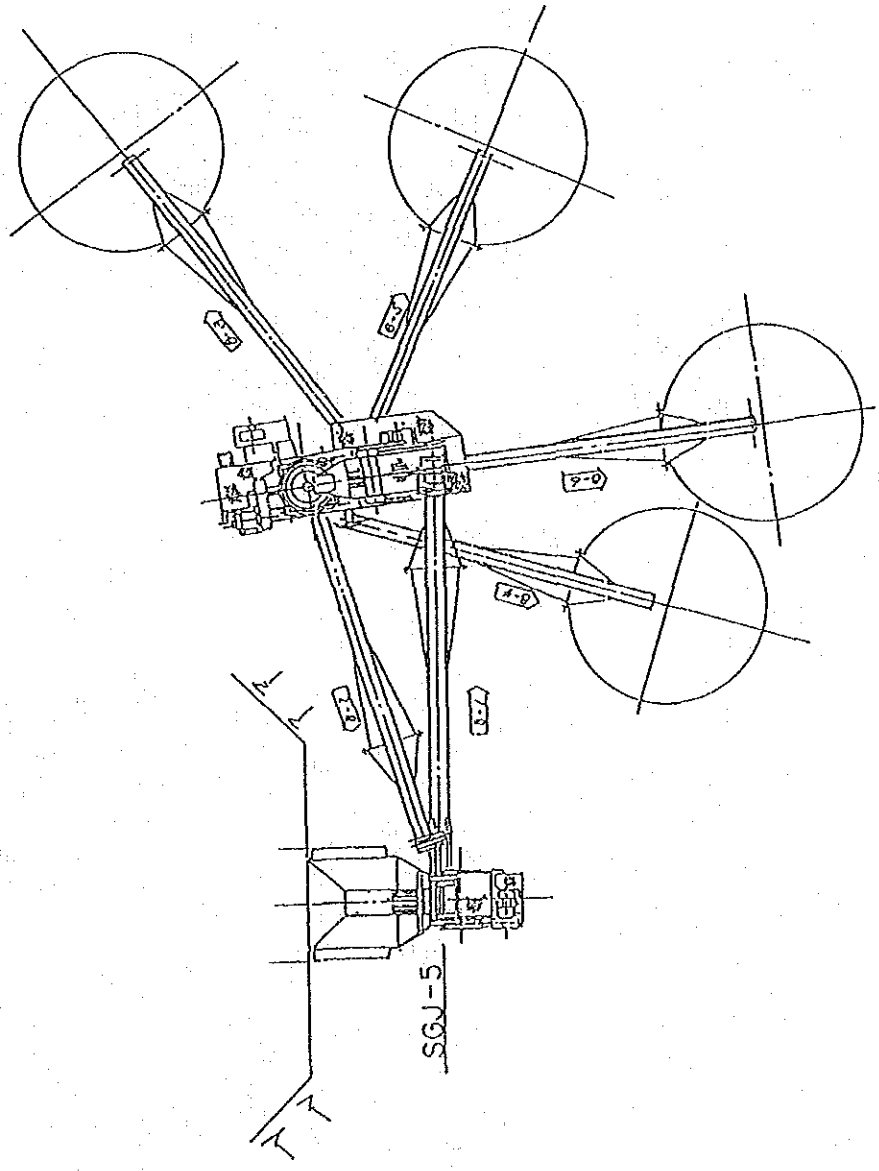
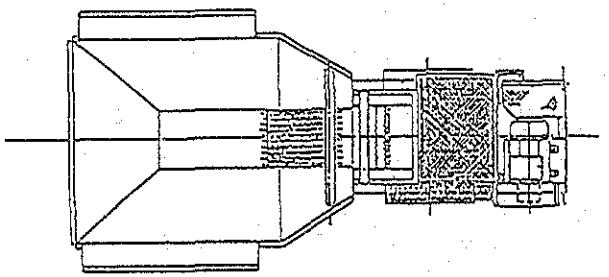
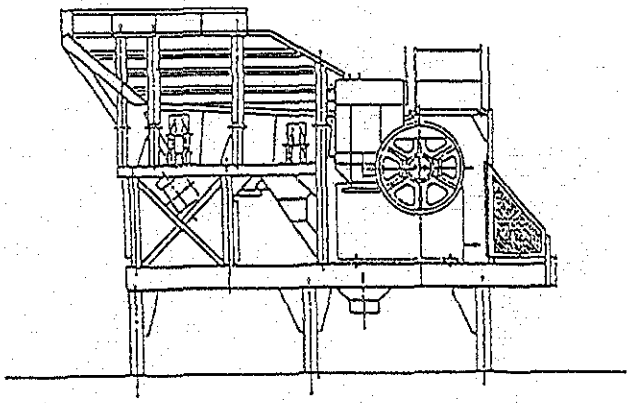


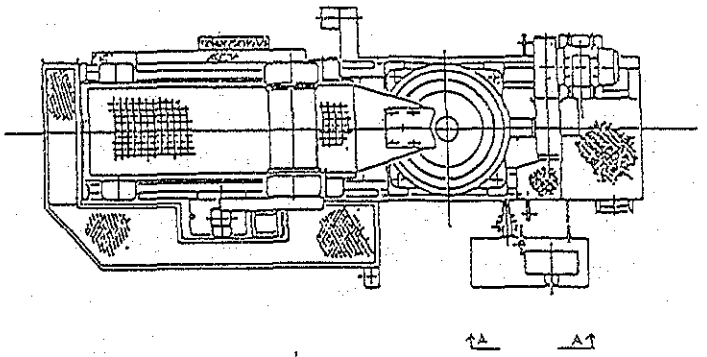
Fig. 4-18 Layout of Crusher

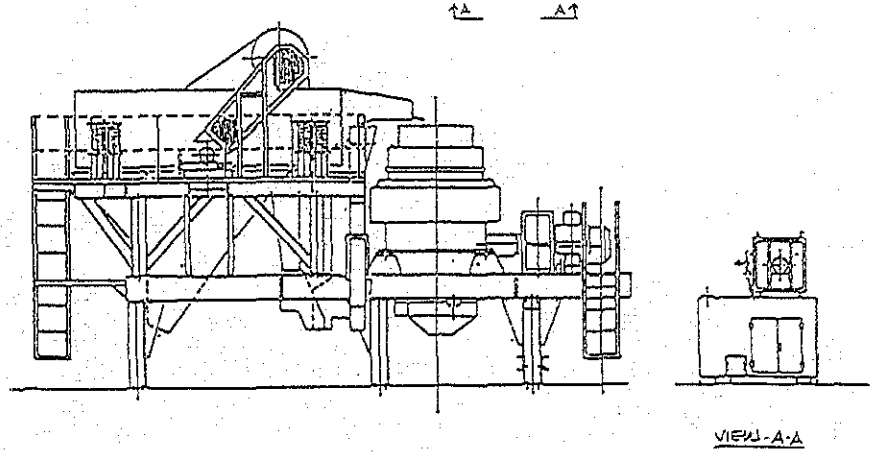
Fig. 4-19 Structure of Crusher





Primary Crusher





Secondary Crusher

MOT and PWD are the executing organizations of the Project in Western Samoa for the port facilities and the quarry plant respectively. For the execution of this project, close cooperation and arrangement between Japanese project group and MOT as well as PWD are required. A special attention should be paid the pavement project of the existing container yard financed by ADB to be carried out during the period of the grant aid project. Fig. 4-20 shows organization of construction management.

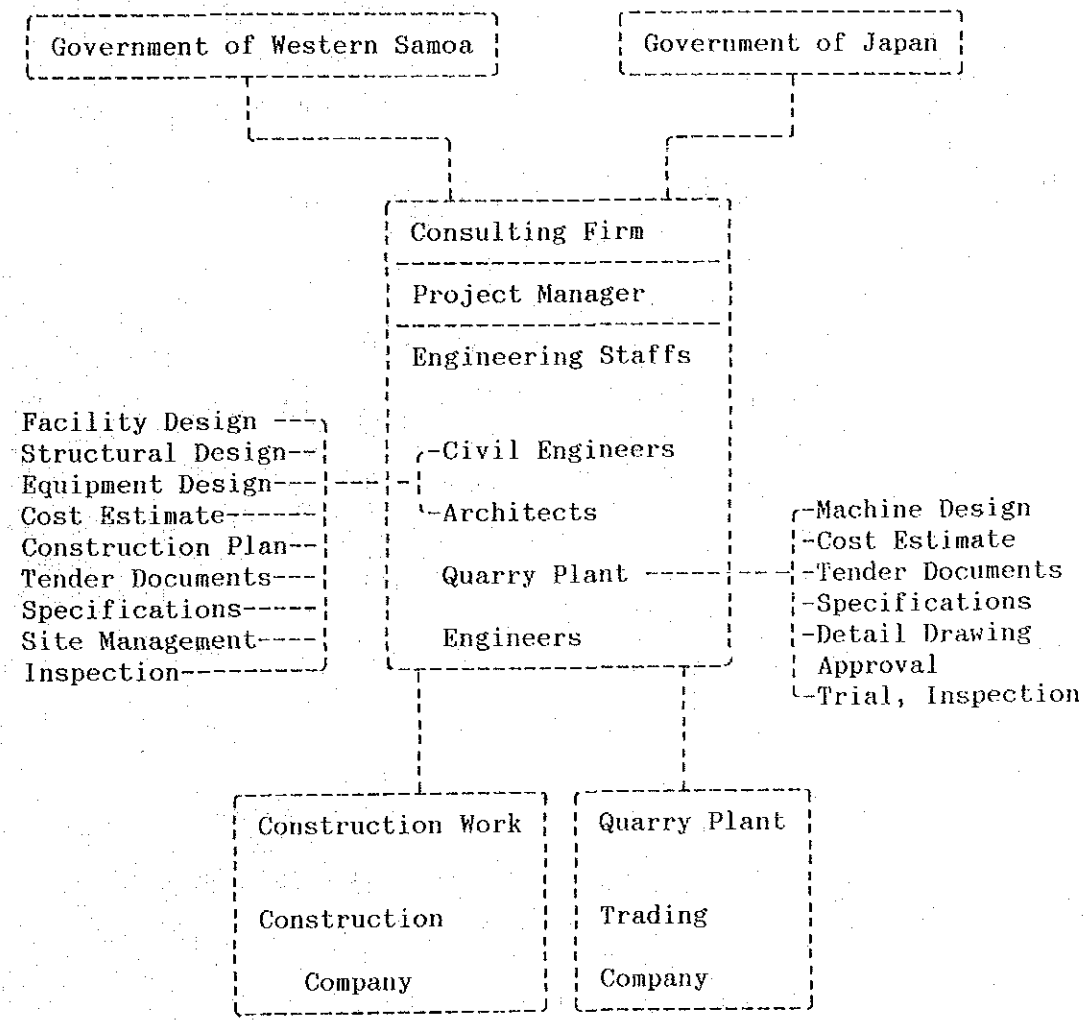


Fig. 4-20 Organization Chart of Project Implementation

(2) Scope of the Grant Aid Project

1) Scope of the grant aid project

The scope of work of the project by the grant aid covers the following items:

i)	Causeway,	Apia Port
ii)	Seawall,	Apia Port
iii)	Quarry Plant	

Project components i) ~ iii) are included in the first phase.

iv)	Breakwater,	Apia Port
v)	Channel Dredging,	Mulifanua Port
vi)	Ferry Ramp,	Mulifanua Port
vii)	-3.5 m Wharf,	Mulifanua Port
viii)	Seawall,	Mulifanua Port
ix)	Navigation Aids,	Mulifanua Port
x)	Navigation Aids,	Salelologa Port
xi)	Pilot/Work Boats,	Apia Port
xii)	Navigation Aids,	Apia Port
xiii)	Wooden Fender,	Apia Port
xiv)	Marine Office,	Apia Port
xv)	Sheds No. 1, No. 3	Apia Port
xvi)	Aleipata Lighthouse	
xvii)	Apolima Lighthouse	
xviii)	Malua Reef Lighthouse	

2) Undertakings by the Government of Western Samoa

The following are the items to be undertaken by the government of Western Samoa under its responsibility.

1) Demolition of the existing marine office
2) Installation of water main to the new marine office
3) Installation of primary power line to the new marine office

4) Installation of primary telephone lines to the new marine office
5) Construction of concrete foundation of a crusher
6) Domestic transportation of a crusher
7) Assembling of a crusher

4.4.2 Construction Conditions and Implementation Plan

(1) Construction conditions in Western Samoa

1) Working hour

Normal working hour : 7:30-12:00, 13:00-16:30
Total 8 hrs/day

Working day : Monday to Friday

Overtime payment : 50% increase (100% for public holidays)

2) Construction Standard

Both civil and building works are based on the Japanese Standard, while the New Zealand Standard are followed for electrical works.

3) Annual working days

Annual working days except holidays and bad weather days can be assumed 200 days.

Working days at sea can be assumed as almost the same as those on land, because both Apia and Mulifanua Ports are well sheltered from offshore waves by surrounding reef.

4) Construction equipment

Special work vessels and construction equipment are not locally available, while small size construction equipment are locally available.

5) Construction Materials and Construction cost

Most of construction materials, such as cement, steel, asphalt, etc. have to be imported, while armour stone, crushed stone and sand are locally available.

(2) Implementation Plan

In planning the implementation schedule, the followings shall be given a special attention.

1) Construction schedule should be planned by taking into consideration such natural conditions as rainfall, wind, wave, etc.

2) Work schedule of the other projects should be coordinated with this project.

3) Number, time and period of Japanese experts should be minimized.

4) Use of local material should be maximized.

5) Upmost attention should be paid in the channel dredging work in a rainy period of November through March.

6) The construction work of the second phase will be carried out in several sites for many items requiring efficient and appropriate control program.