X. PLAN OF EXECUTION

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1. Outline and Division of Work

This project consists principally of dredging to widen and deepen the Canal in a volume of approximately 400 million m^3, as accompanied by transfer of revetments for 130 km, earthworks of approximately 70 million m^3, breakwater extension work at Port Said for approximately 5 km, etc.

1-1 Dredging

Since no dredgers are available in Egypt except a few owned by the Canal Authority, the greater part of the dredging work has to be carried out by foreign contractors. The execution assignment includes 3 sections, i.e. the yen-loan section where executing contractors have already been assigned, the section for which international tenders are to be invited in future, and the section where the work is to be executed directly by the Canal Authority. All these sections are exhibited in Fig. 10-1-1.

The yen loan section includes Lots A, A_2, B and C for the total earth volume of 122.5 million m^3. The section for future international bid includes Lot D, the waterway to the south of Port Tewfik and west branch side of Kabret By-pass which has double channels, Lots E, F and G inside Great Bitter Lake, Lots H and J between Great Bitter Lake and Timsah Lake, and Lots K and L between Ballah and El Cap, for the total earth volume of 236 million m^3. The section to be covered directly by the Canal Authority is expected to extend from El Cap (35-km point) to the channel entrance of Port Said with a total earth volume of 114 million m^3.

1-2 Revetment

The revetment removal work is planned to transfer the east bank for about 120 m to the back, in consideration of the future widening project. However, where corrections are to be made to the curvature on the bends of the Canal, both banks on the east and west sides have to be transferred. In addition, transfer of mooring bollards is also included in this revetment work.

Whole of this work is to be executed by local contractors. However, removal of some concrete mooring bollards installed in water will be executed by foreign contractors.

1-3 Earthworks

Excavation on the land section of the Canal extension sites is to be done by earth-moving machine. This work also includes removal of concrete military structures and banking for construction of dumping sites for the dredged soil.

These earthworks are to be executed by local contractors.

1-4 Breakwater and Navigation Aids

Breakwater work is intended to extend the existing breakwater outside Port Said approximately 5 km towards offing. This work is required to prevent the siltation of the fairway by driftsand, which is liable to occur as the fairway is deepened and extended towards offing. It is to be executed under direct control of the Canal Authority.

It is planned that the Canal Authority will also place an order for new tugboats and transfer light buoys and mooring buoys.

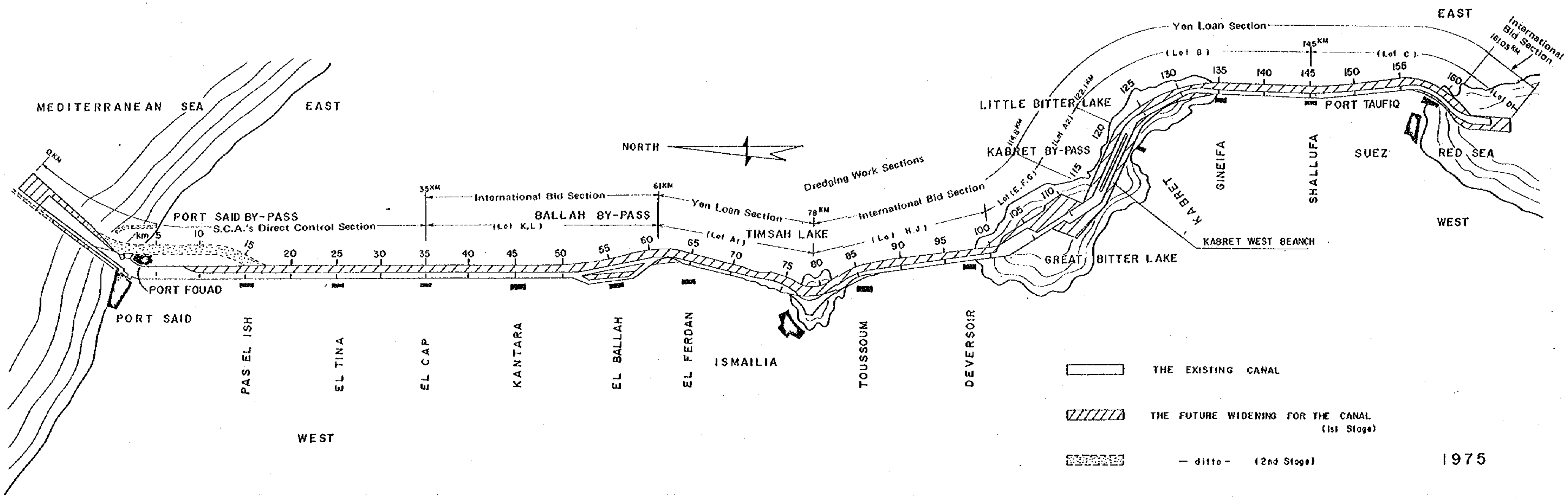


Fig. 10-1-1 Division of Dredging Work Sections

2. Execution

2-1 General

In order to execute the work, the construction bases are to be provided at Suez, Ismailia and Port Said. For transportation of materials, the Canal itself is available and roads are maintained in good condition along the Canal, so that no problems are expected to develop. Landing of imported equipment and materials will pose no problems either because Port Said and Suez are equipped with necessary facilities.

In regard to labor, unskilled labor force can be readily recruited at relatively low wages, but since seamen and machine operators are limited in number, it is recommended that local workers be given technical training in a systematic way or by delegation to the executing contractors in the course of the project, so as to secure more skilled workers.

In the aspect of construction materials and equipment, it is of course necessary to maintain quarries and shipping facilities in order to assure smooth supply of material stones (approximately 100 million m^3) for construction of the breakwater at Port Said. Except for this supply of materials, execution is expected to pose no problems since the principal part of this project is dredging which does not require any mass procurement of material. As regards equipment, however, it may be found difficult to hire a large number of large suction dredgers. It is expected that as many as 20 dredgers will be needed in addition to those required by the Canal Authority for the yen-loan section. Orders should therefore be placed with the contractors well in advance so that they may have enough time to secure the necessary dredgers.

For maintenance and repair of working crafts, a dock yard for large boats is available at Port Said, and repair and maintenance facilities for medium and small boats are also in operation at Port Twefik and Ismailia. These facilities are either directly controlled by or related with the Canal Authority and thought to be able to repair the working crafts engaged in the project. However, their facilities were damaged by war and although efforts are made to restore their pre-war function, only part of them are in serviceable condition at present. It is urged that these docking facilities, elevated facilities, machine tools and other related activities be completely restored to their original condition before beginning the work. In addition, because spare parts of special equipment have to be procured from foreign sources, sufficient quantity of such replacement parts should be kept in stock so as to assure quick repair without any obstacles to the progress of the work.

2-2 Dredging

2-2-1 Yen-loan Section

The yen-loan section permits smooth dredging by suction dredgers although hard layers containing sandstone are found in Lot C. However, considering the large volume of earth to be dredged, safety of mobilization and economy, it will be necessary to put large dredgers in operation. In those ports of Lot C where hard layers are found, large dredgers with powerful cutters should be employed and in addition, it is necessary to establish a system under which worn and torn parts, such as cutter tips, can be efficiently and carefully replaced or repaired.

Dumping site is to be provided 200 m away from the Canal water front on Sinai peninsula side by banking to be performed separately. The piping in the Canal must be frame-supported or sunk in part, but the floater type will suffice for almost all parts. On land, the disposal pipeline need to be only laid on the ground. The piping arrangement at the dumping site is to be made into a vein shape, since the dredged earth is sandy. The average discharging distance is about 2,500 m which is within the span of large pump dredgers' capabilities.

In order to complete the work before the end of the construction period, 10 or more fleets of the 8,000 HP class dredgers are required computing from the amount of workload. The standard organization of a fleet is to be as follows:

Suction Dredger (8,000 HP Class)	1
Anchor Boat (20 t capacity)	1
Pontoon (500 t)	1
Oil Barge (120 m^3)	1
Water Boat (120 m^3)	1
Tugboat (180 HP Class)	1
Launch (50 HP)	1
Besides above,	
Sand Discharging Floater Pipe	Approx. 5,000 m

This list does not include a tugboat for the pump dredger, which may be hired as necessary.

Mobilizing trips of the dredgers from Japan are recommended to be made during the period from October to the beginning of April to avoid the monsoon on the Indian Ocean and the typhoon on the Pacific Ocean.

2-2-2 International Bid Section

Lot D outside Port Tewfik has hard layers including sandstone of which property and quantity are to be determined in the results of a coming survey. However, a larger quantity of hard rocks than found in Lot C is anticipated. In this section, therefore, only the part which can be dredged by suction dredgers may be covered and for the rest where the bed cannot be excavated by dredgers it is most reasonable to remove crushed pieces by bucket dredgers after blasting the bed. At any rate, since this section contains hard bedrocks and calls for dredging in the outer ocean, it involves a number of problems like weather evacuation of working crafts, low work efficiency, etc. which may require a precise review of the execution plan after learning the result of soil survey. Note that the earth dumping site in this section is provided at a submarine depth near the shore of Sinai peninsula.

In other lots of the international-bid section, all work can be executed by suction dredgers just as in the yen-loan section.

Since the work begins 9 months later than the yen-loan work, the following crafts will be required in order to complete in the same time as the yen-loan section: total 19 fleets of suction dredgers (8,000 HP class), 7 fleets in the Canal, 10 fleets in Bitter Lake fairway and anchorage and 2 fleets in the fairway off Port Tewfik. Besides, for dredging into the ocean off Port Tewfik, 10 or more fleets of large bucket dredgers will have to be mobilized.

2-2-3 Canal Authority's Direct Control Section

In the Canal Authority's direct control section, the part inside the Canal is good for the Authority's pump dredgers or bucket dredgers, while the fairways at Port Said Harbor for trailing suction dredgers. Since the dredging inside the Canal deals with soft beds, no technical problems will be involved. The dredging of Port Said fairways by trailing suction dredgers will neither involve any hardship except that the location of the earth dumping site should preferably be provided near the shore but not too close to it as to cause deterioration of the dredging efficiency, so that it will serve as a sand by-pass to the erosion part on the eastern coast.

Total amount of directly controlled work has to be carefully planned in proper proportion to the working craft capabilities, including those of the newly built crafts of the Authority.

2-3 Revetment

Most part of the existing bank is protected by sheeting in the lower part and by sloped stone-pitching in the upper part so that it can offset ship waves by their runup.

This structure may be the only one to be followed basically after the removal. The removed materials may be reused to save the cost.

2-3-1 Design of Revetment

There have been devised more than 20 types of different revetment structures, but none have proved to be truly satisfactory.

The revetment has an extension of about 120 km on one side, so that it has a total extension of about 240 km. It is likely that the cost of its construction and maintenance will largely affect the Canal operation.

The most serious problem to be considered in the revetment construction is the possible collapse which could result from the ship waves and tidal current and the resultant outflow of backfilled sand.

Note must therefore be taken of the fact that the collapse of a revetment is often affected by the cruising speed of vessels and sectional area of fairways.

(1) Design Condition

Table 10-2-1 shows the design condition of the revetment.

From the past experiments, it is estimated that the largest ship wave at a given design sectional area of fairway and a given cruising speed is 100 cm for negative wave and 30 cm for positive wave. Accordingly, the maximum negative wave of 100 m is expected to work on the revetment as residual water pressure.

The design tidal levels (HWL and LWL) are the values recorded at respective points which are described in Section 1 (Natural Condition) of Chapter VI.

Earthquakes are not considered because Egypt is free from them.

Table 10-2-1 Design Condition of Revetment

Area (km)	Soil Type	Internal Friction Angle of Soil	Soil Weight per Unit Volume	Soil Weight per Submerged Unit Volume
5 ~ 62	Clay containing sand	25°	1.8 t/m³	1.0 t/m³
62 ~ 145	Sand	30°	1.8 t/m³	1.0 t/m³
145 ~ 158	Sand containing gravels	35°	1.8 t/m³	1.0 t/m³

(2) Determination of Structure

A variety of structures can be conceived, however, after a careful review, the one proposed by the Canal Authority is favorably regarded with respect. The following 3 points are noted in designing.

1. To perform adequate functions as a canal bank.
2. Economy.
3. To be constructed in line with the social welfare activities, another objective of this project.

A gentle slope of a stone-pitched bank prevents the earth from falling while a rough surface thereof has certain effects in offsetting wave impact.

The stone-pitching work may require a large number of labor hands, but in Egypt it is more economical to resort to manpower than to piles because wages are rather low.

The material stone used for the existing bank can be re-used so that only the quantity in short has to be transported from the quarries in Mt. Attaqa.

Since the project also aims at unemployment relief, the stone pitching work where many laborors can be employed is to be favorably accepted.

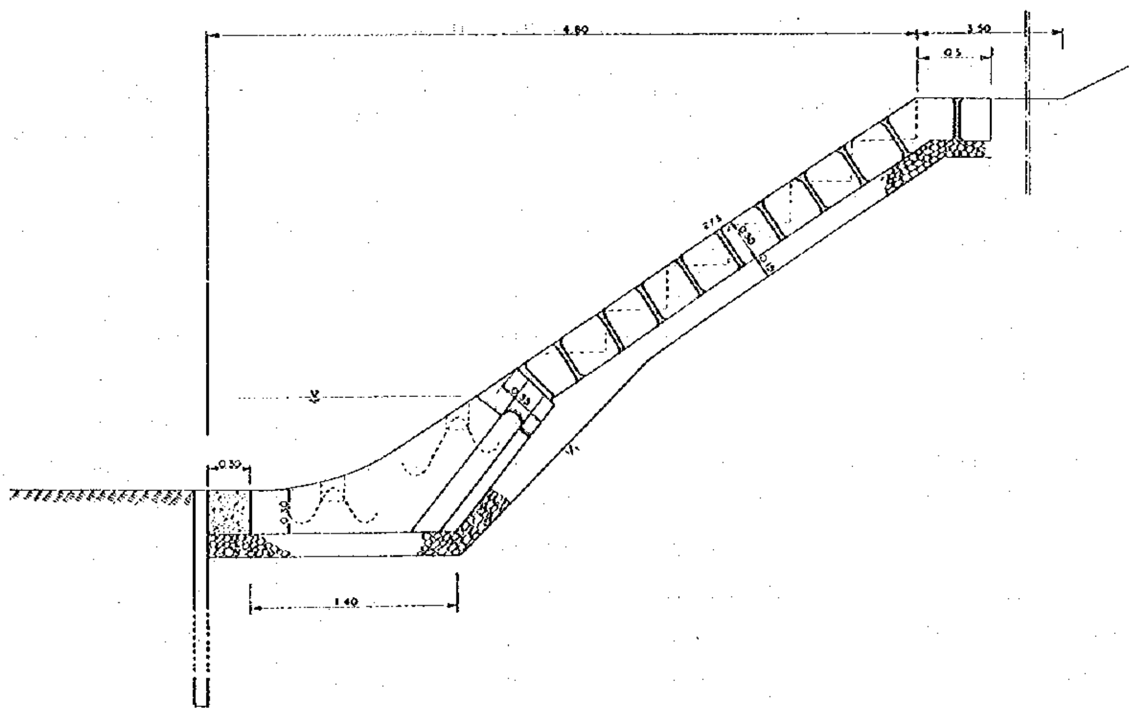


Fig. 10-2-1 Design Cross-section A (Revetment)

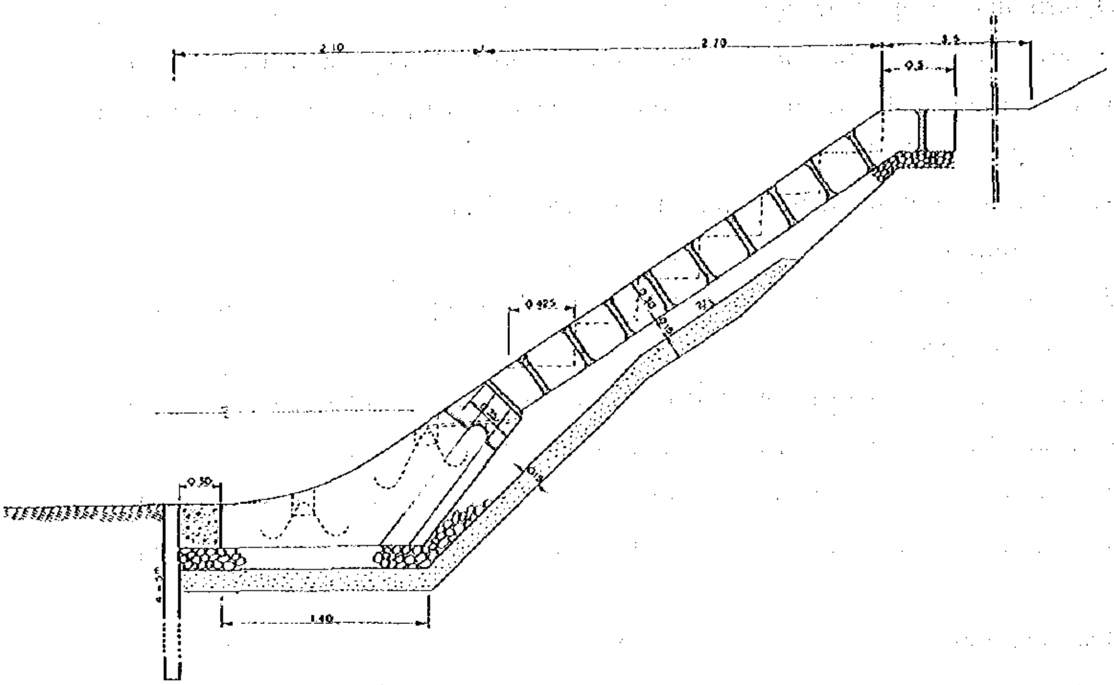


Fig. 10-2-2 Design Cross-section B

Table 10-2-2 Cross-section Allocation

Section (km)	Cross-section	Crown Height (m)	Berm Height (m)	L.W.L. (D.L.) (m)	Pile Type and Length (m)
5,150 ~ 25,000	C	19.60	17.00	18.10	U–II 5 m
25,000 ~ 38,000	B	19.60	17.00	18.10	U–II 5 m
38,000 ~ 44,500	A	19.60	17.00	18.10	U–II 5 m
47,000 ~ 47,500	A	19.60	17.00	18.15	U–II 5 m
47,500 ~ 49,000	C	19.60	17.00	18.15	U–II 5 m
49,000 ~ 51,000	A	19.60	17.00	18.15	U–II 5 m
51,000 ~ 59,000	C	19.60	17.00	18.15	U–II 5 m
59,000 ~ 76,000	A	19.60	17.00	18.20	U–II 5 m
82,052 ~ 85,000	C	19.80	17.20	18.20	U–II 5 m
85,000 ~ 94,500	A	19.80	17.20	18.25	U–II 5 m
94,500 ~ 97,732	C	19.80	17.20	18.25	U–II 5 m
134,482 ~ 145,000	B	19.80	17.20	18.20	U–II 4 m
145,000 ~ 155,500	C	19.80	17.20	18.20	U–II 4 m
155,500 ~ 158,738	B	19.80	17.20	18.20	U–II 4 m

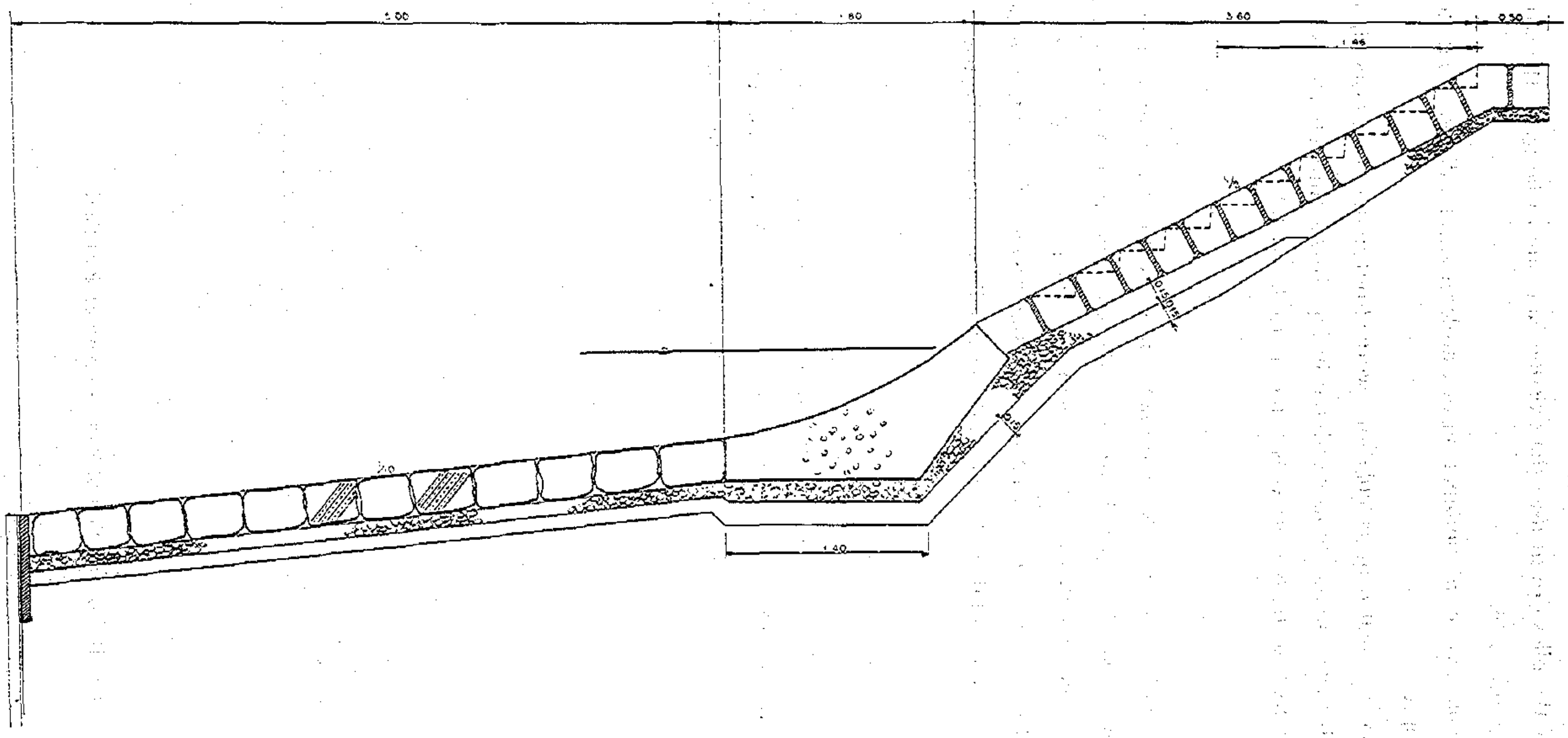


Fig. 10-2-3 Design Cross-section C

In addition, if the piles driven into the existing bank are to be used, the structure will become much more stable.

By the foregoing reasons, a combination of cantilever sheet pile type and stone-pitched type is adopted.

When the bank is designed by calculations worked out under conditions shown in Table 10-2-1, it will have cross-sections exhibited in Fig. 10-2-1 through 10-2-3. Allocation of these cross-sections will be as listed in Table 10-2-2.

2-4 Earthworks

Executing equipment for earthworks on land are to be comprised principally of motor scrapers as supplemented by bulldozers. Some concrete military structures, of which removal has to be executed by blasting and with tractor-cranes, shovel loaders, dump trucks etc., are seen remaining in part. Since the mound of the dumping site can be built by simply stacking sand on the ground, only bulldozers may to be used.

2-5 Breakwater

2-5-1 General

As seen from Fig. 10-2-4 and 10-2-5, the breakwater has a submerged rubble mound structure. Rubbles for this riprap work can be collected in Mt. Attaqa, located to the west of Suez, and hauled by truck or railway to a suitable place in the vicinity of Suez, where a

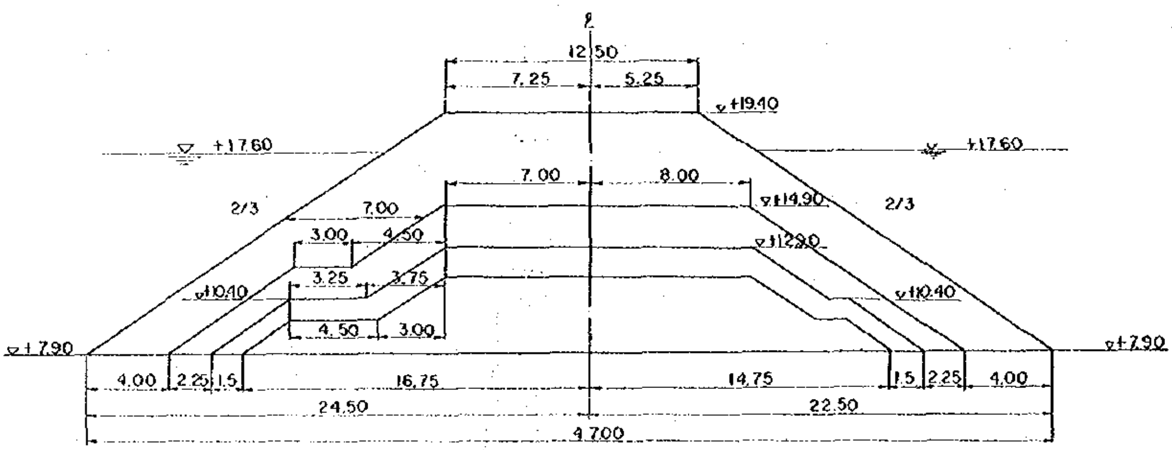


Fig. 10-2-4 Section of West Breakwater, Port Said

shipping site is provided for transfer onto stone hauling boats and transpartatim to the breakwater construction site through the Canal.

2-5-2 Design of Breakwater

Only extension of the west breakwater of Port Said is involved in the Breakwater Plan of the First Phase Extension Project and a structure as proposed by the Canal Authority is adopted.

The existing west breakwater has an extension of 7,354 meters from the lighthouse at its shoreside end, and points to NNW nearly in parallel with the fairway. It was built to cut the invading waves and protect the entrance channel from the west to east littoral drift. Therefore, the mound structure is adopted based on economy, availability of materials, execution methods and bearing capacity of ground. It is formed into a breakwater as far as 4,500 m from the base, and its 4,500 ~ 7,354 m section is submerged. The head is submerged in order that the function of a breakwater will be exhibited while the decrease of the bearing capacity towards offing will be compensated.

These factors may as well be taken into account for the planned extension of the submerged section. In consideration of the soft submarine bed, the foundation is to be formed with quarry refuse or sand, over which the upper part of a mound structure is to be built in the same way as the existing breakwater, with the crown height set

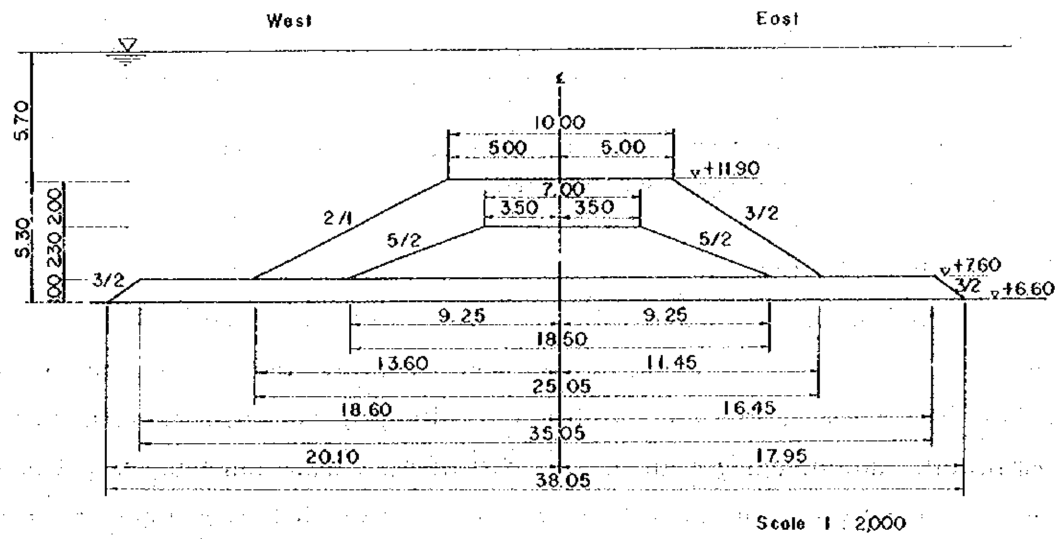


Fig. 10-2-5 Port Said West Breakwater (Design Cross-section of Extended Submerged Section)

at half the water depth so as to prevent deposition of drift sand in the entrance channel.

The crown width is to be 10 m (constant), which is as large as that of the existing breakwater, but the bottom breadth is to varied proportionately to the water depth.

The mound foundation work will require some review in respect of thickness, material, displacement method, etc. after a survey of the submarine bed.

In addition, it is concluded to be proper that the submerged section be extended as far as the point of 15.0 m water depth, basing on the siltation survey by water depth and considering the result of cost comparison between the submerged section and the fairways maintenance dredging.

The design cross-section and extension of the submerged section, as determined from the above standpoint, are shown in Figs. 10-2-5 ~ 7.

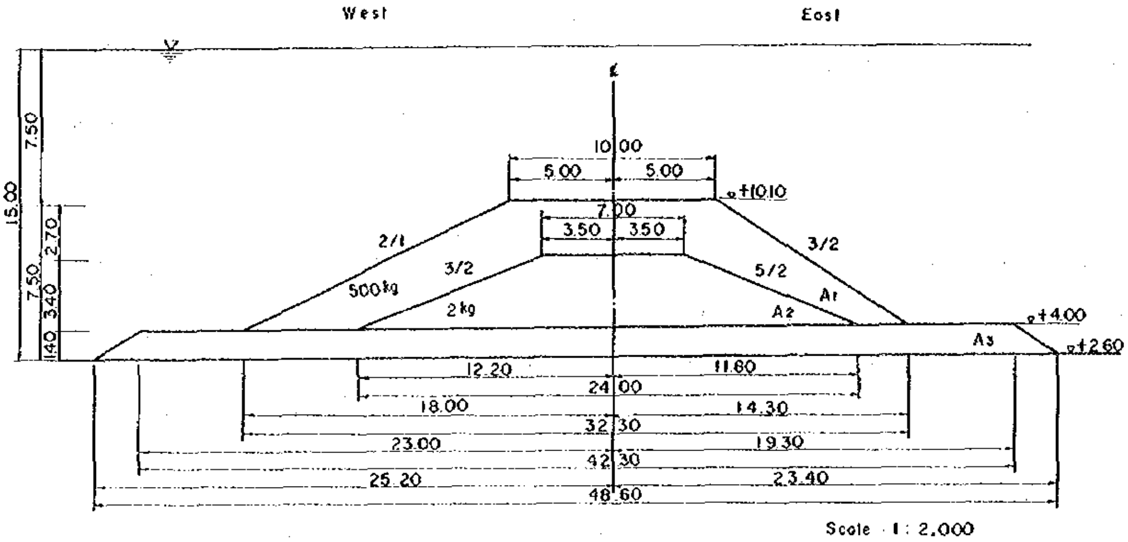
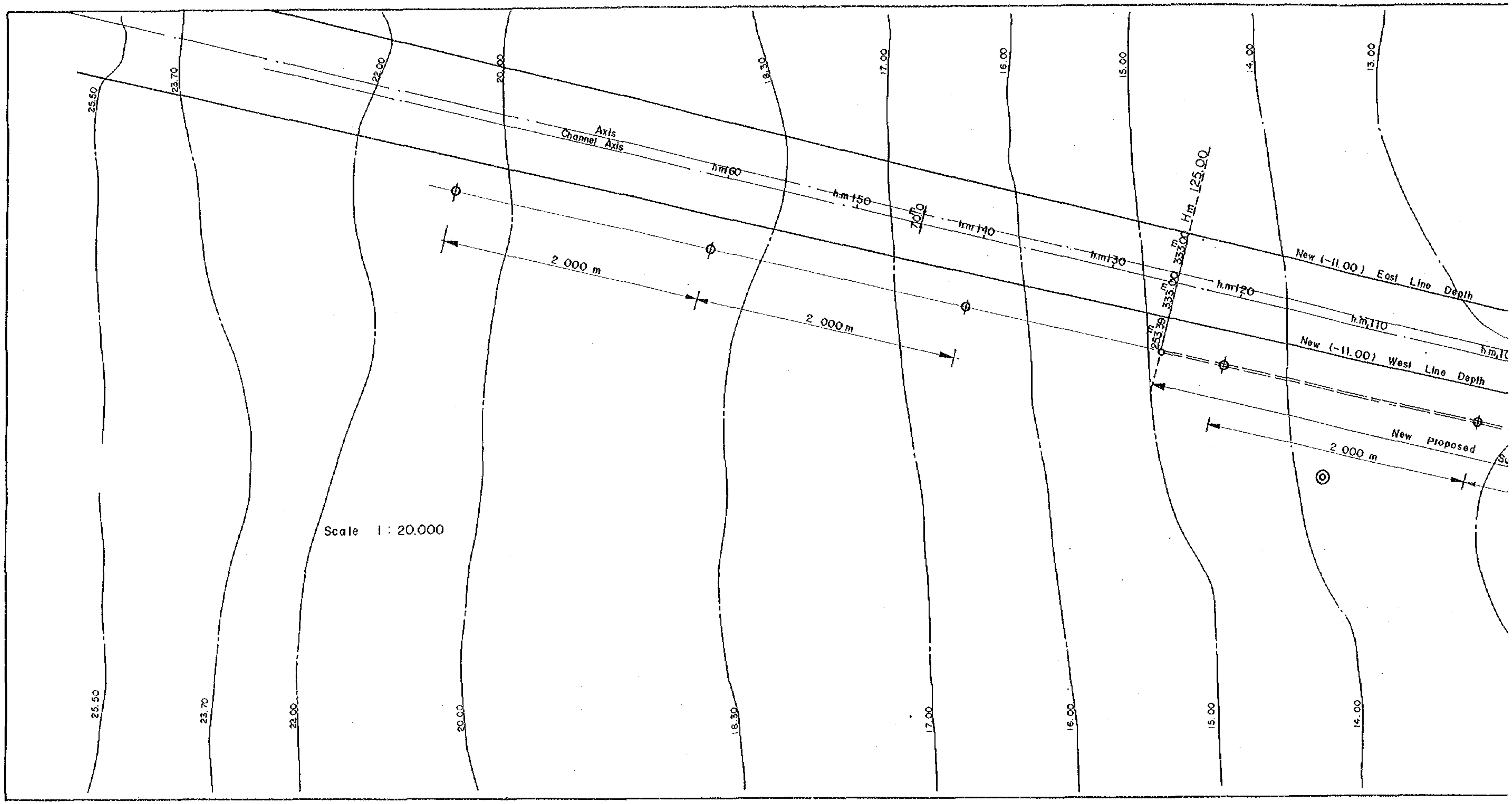


Fig. 10-2-6 Port Said West Breakwater (Design Cross-section of Extended Submerged Section)

3. Coordination of Execution

In the coordination required among different types of work involved in the project, priority shonld be giuen to the revetment removal and earthworks over the dredging work. This is because there are some lots which call only for dredging and not for revetment removal or earthworks, and dredging in the greater part of the Canal cannot be started before completion of the revetment removal and earthworks. However, if the revetment removal progresses too far ahead of the dredging, slope failure could occur before the Canal is widened and deepened by dredging and this could result in the inability to maintain



25.50
23.70
22.00
20.00
18.30
17.00
16.00
15.00
14.00
13.00
Axis
Channel Axis
h.m160
h.m150
h.m140
h.m130
h.m120
h.m110
700
Hm 125.00
333.00
253.39
2 000 m
2 000 m
2 000 m
New (-11.00) East Line Depth
New (-11.00) West Line Depth
New Proposed
Scale 1 : 20.000

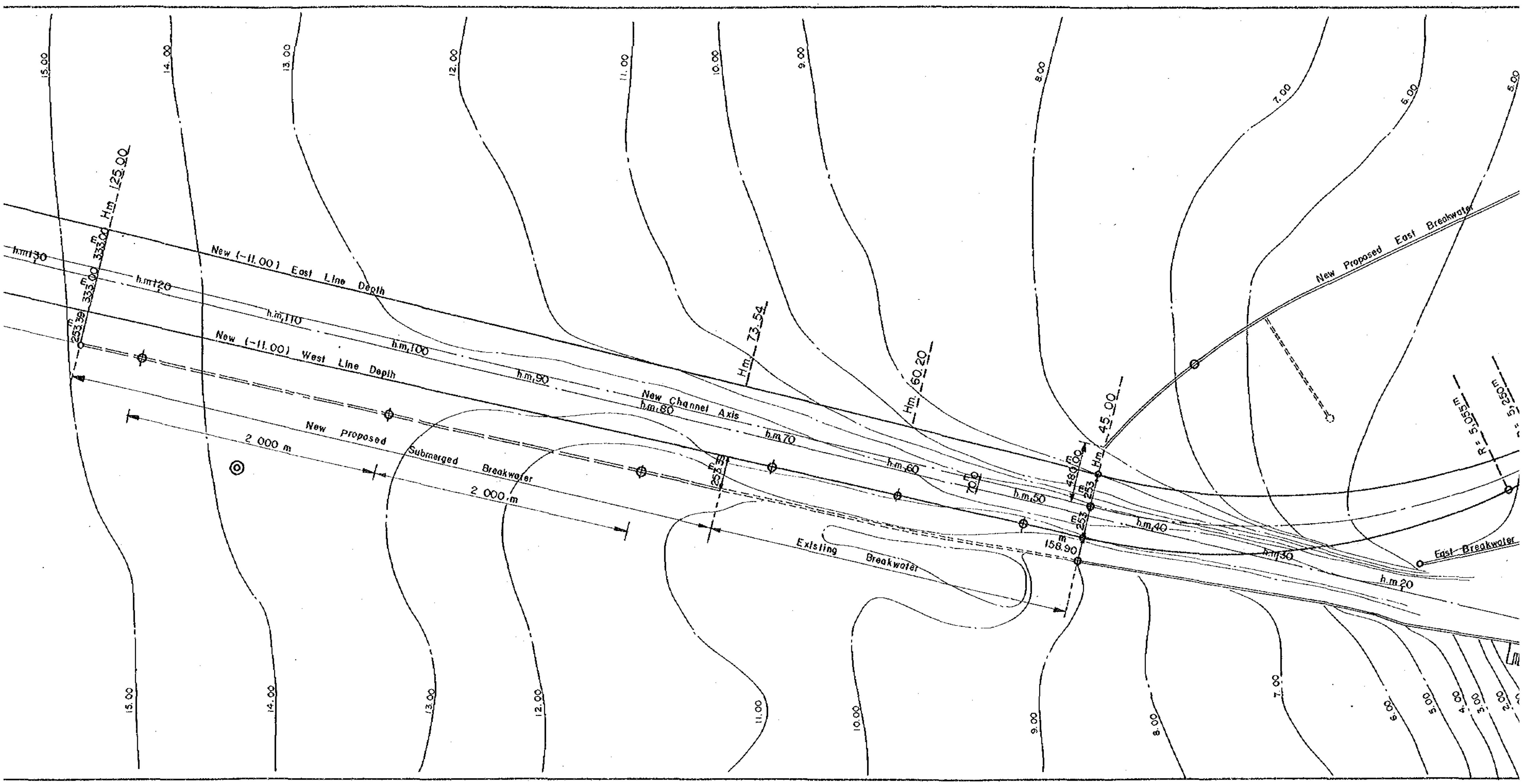
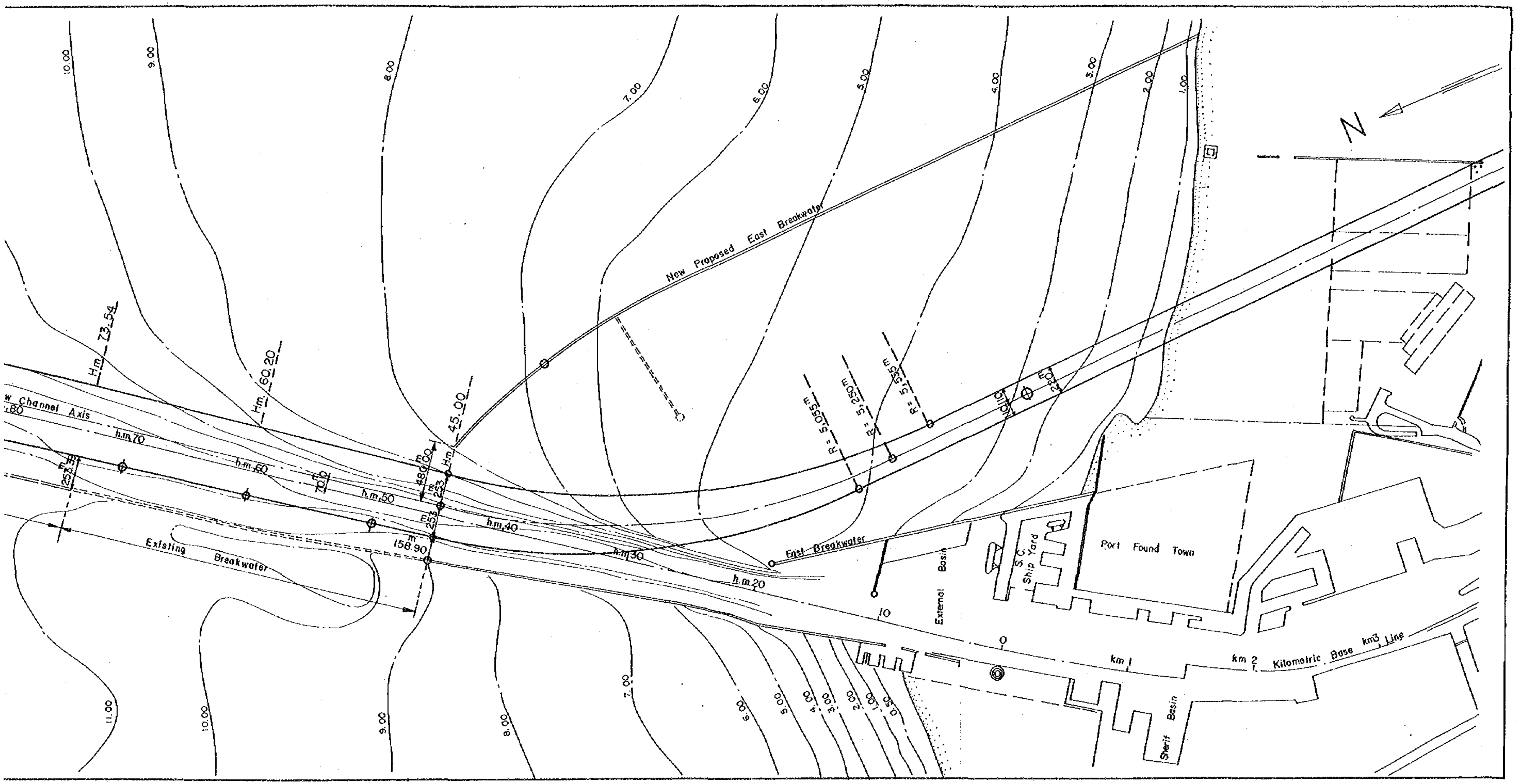


Fig. 10-2-7 Port Said West Breakwater Plan


New Proposed East Breakwater
East Breakwater
Existing Breakwater
Channel Axis
External Basin
S.C. Ship Yard
Port Found Town
Sherif Basin
Kilometric Base Line
km 1
km 2
km 3
N

Plan

the existing water depth. Besides, different contractors are expected to be assigned for the execution of the dredging work, revetment removal and earthworks and this project is so large in size that an enormous number of dredgers will be at work, thus it is very important that coordination among these types of work be properly conducted by the Canal Authority.

4. Construction Cost

4-1 Yen-Loan Work

Total costs of yen-loan work are shown by the type of working craft and work items in Table 10-4-1 and by individual lot in Table 10-4-2.

The costs were calculated on the following conditions.

1) Unit costs are based on the 1974 commodity price, and any price rise from inflation thereafter is not considered.

2) The foreign currency portion of the construction costs is required for procurement of materials, equipment and working crafts not available in Egypt as well as for services to be paid in foreign currency.

3) No import tax is included in the cost of construction equipment from foreign countries.

4) Compensation for fishermen and cost of land acquisition incidental to the construction work are excluded.

5) In the calculation of yen-loan section itemized costs, Japanese Construction Cost Estimation Standard and Rental Table have been referred to as a basis.

Table 10-4-1 Cost of Yen-Loan Construction Work

Classification	Designation	Type & Dimensions	Operation or Stand-by	Unit	Quantity	Unit Price			Amount		
						Local Currency	Foreign Currency	Total	Local Currency	Foreign Currency	Total
						L.E.	L.E.	L.E.	L.E. 1,000	L.E. 1,000	L.E. 1,000
Dredger	Suction dredger	Non-propelling, D8000PS	Operation	Day	8,100	2,410	4,360	6,770	19,651	35,268	54,919
	〃	〃	Stand-by	Day	1,350	590	2,110	2,700	803	2,854	3,657
					9,450	3,000	6,470	9,470	20,454	38,122	58,576
Auxiliary vessel	Anchor barge	Steel built, self-propelling, D230PS, 20t capacity	Operation	Day	3,150	49	43	92	155	136	291
	〃	〃	Stand-by	Day	300	15	31	46	5	9	14
	Pontoon	Steel built, non-propelling, 500t loading capacity	Operation	Day	900	15	13	28	13	12	25
	〃	〃	Stand-by	Day	5,250	3	8	11	17	42	59
	Water boat	Steel built, non-propelling 120 m^3	Operation	Day	2,700	7	5	12	19	13	32
	〃	〃	Stand-by	Day	7,200	2	3	5	17	22	39
	Oil barge	Steel built, non-propelling 120 m^3	Operation	Day	1,700	7	5	12	12	8	20
	〃	〃	Stand-by	Day	8,200	2	3	5	19	25	44
	Tugboat	Steel built, D180PS	Operation	Day	5,300	23	15	38	120	79	199
	〃	〃	Stand-by	Day	850	7	12	19	6	10	16
	Launch	Steel built, D50PS	Operation	Day	10,000	10	5	15	97	47	144
	〃	〃	Stand-by	Day	200	4	3	7	0.8	0.7	1
	Total					144	146	290	480	406	886
Discharge pipe work	Discharge pipe	760 mm x 6 m	Operation	Day	8,100	36	124	160	292	1,005	1,297
	〃	〃	Stand-by	Day	2,820	28	175	203	78	494	572
	Floater	1,400 mm x 4.5 mm	Operation	Day	8,100	40	145	185	323	1,176	1,499
	〃	〃	Stand-by	Day	2,820	12	71	83	33	200	233
	Rubber joint	760 mm x 1.6 m	Operation	Day	8,100	25	160	185	202	1,297	1,499
	〃	〃	Stand-by	Day	2,820	12	80	92	35	224	259
	Connecting pipe	Installation and removal		Set	150	706	451	1,157	106	68	174
	Pipeline support (on land)	〃		Set	10,050	2	0.1	2	21	1	22
	Water boat	〃		Set	75	260	157	417	19	12	31
	Discharge pipe (on sea)	〃		Set	1,500	231	154	385	347	231	578
	Discharge pipe (on land)	〃		Set	10,050	35	2	37	353	18	371
	Total					1,387	1,520	2,907	180.8	4,727	6,535
Mobilization and transportation	Fleet	1 set		Fleet	10	–	–	–	0	5,826	5,826
Land equipment	Truck	12t	Operation	Day	1,000	25	0	25	25	0	25
〃	Crane	15t	Operation	Day	1,000	58	0	58	58	0	58
	Total			Day		83	0	83	83	0	83
Others	Travelling expenses			Person	290	0	1,540	1,540	0	446	446
Grand total									22,825	49,527	72,352

Table 10-4-2 Yen-Loan Work Construction Cost by Lot and Work Type

Unit: L.E. 1,000

Lot	Currency	Pump Dredger	Auxiliary Vessel	Sand Pipe Work	Land Equipment	Mobilization and Transportation	Others	Total
A_1	Local	3,450	82	307	14	0	0	3,853
	Foreign	6,366	69	804	0	990	76	8,305
	Total	9,816	151	1,111	14	990	76	12,158
A_2	Local	1,205	28	107	5	0	0	1,345
	Foreign	2,247	24	279	0	344	26	2,920
	Total	3,452	52	386	5	344	26	4,265
B	Local	5,273	123	463	21	0	0	5,880
	Foreign	9,852	104	1,210	0	1,492	114	12,772
	Total	15,125	227	1,673	21	1,492	114	18,652
C	Local	10,526	247	931	43	0	0	11,747
	Foreign	19,657	209	2,434	0	3,000	230	25,530
	Total	30,183	456	3,365	43	3,000	230	37,277
Total	Local	20,454	480	1,808	83	0	0	22,825
	Foreign	38,122	406	4,727	0	5,826	446	49,527
	Total	58,576	886	6,535	83	5,826	446	72,352

4-2 Gross Project Cost

Gross construction costs by work type are listed in Table 10-4-3.

5. Work Schedule Plan

5-1 Work Schedule

The schedule of work by types is shown in Table 10-5-1.

Dredging work in the yen-loan section is to be carried out within the Canal and therefore few limitations to the field work are expected from weather and ocean conditions. Uncertain factors involved in the work schedule would be accidents caused by explosion which result in the exposure of harder layers than anticipated. By reason of these factors, the work schedule should be planned with an ample time allowance.

If the average daily operational hours of a suction dredger is 16 hours and the annual number of working days is 270 days, employment of 10 fleets of 8,000 PS class will suffice for completion of the whole work within the construction period shown in Fig. 10-5-1.

The dredging work in the International Bid Section will require employment of as many as 19 fleets of 8,000 PS class suction dredgers in order to catch up with the yen-loan section, as mentioned earlier.

Table 10-4-3 Project Construction Costs by Type of Work

Type of Work	Section	Lot	Quantity	Unit Cost: Local Currency	Unit Cost: Foreign Currency	Unit Cost: Total	Amount: Local Currency	Amount: Foreign Currency	Amount: Total	Remarks
Dredging	Yen-loan section	A_1	10^6m^3 39.7	L.E./m^3 0.097	160 ¥/m^3 0.209 L.E./m^3	L.E./m^3 0.306	10^3L.E. 3.850	10^6¥ 6.370 8.310 10^3L.E.	10^3L.E. 12.160	Foreign currency is expressed in yen in the upper column and is Egyptian pounds in the lower column.
		A_2	10.1	0.134	222 0.290	0.424	1.350	2.240 2.920	4.270	
		B	39.6	0.148	247 0.322	0.470	5.880	9.800 12.770	18.650	
		C	33.1	0.354	591 0.771	1.125	11.750	19.590 25.530	37.280	
		[Total]	[122.5]				[22.830]	[38.000] [49.530]	[72.350]	
	International bid section	H.J.K.K.	10^6m^3 101.9	L.E./m^3 0.097	L.E./m^3 0.209	L.E./m^3 0.306	10^3L.E. 6.660	10^3L.E. 24.520	10^3L.E. 31.180	
		Kabret West Branch	5.3	0.134	0.290	0.424	480	1.770	2.250	
		E.F.G.	116.0	0.134	0.290	0.424	10.500	38.680	49.180	
		D	12.8	0.854	3.146	4.0	10.930	40.270	51.200	
		[Total]	[236.0]				[28.570]	[105.240]	[133.810]	
	SCA's direct control section		10^6m^3 114.0	L.E./m^3 0.2	L.E./m^3 0.1	L.E./m^3 0.3	10^3L.E. 22.800	10^3L.E. 11.400	10^3L.E. 34.200	
	Total of dredging		[472.5]				[74.190]	[166.170]	[240.360]	
Revetment			km 130	L.E./m 112	L.E./m 25	L.E./m 137	10^3L.E. 14.630	10^3L.E. 3.250	10^3L.E. 17.880	Bank transfer and installation of new facilities incl. bollards.
Earthworks			10^3m^3 67	L.E./m^3 0.329	L.E./m^3 0.329	L.E./m^3 0.448	22.000	8.000	30.000	Earthwork in the canal extension site and creation of dumping site.
Breakwater			km 5	L.E./m 1.400	L.E./m 1.400	L.E./m 2.800	7.000	7.000	14.000	At Port Said.
Navigation aids			1 set				850	15.640	16.490	Tugboats, mooring buoys and buoy lights.
Others							1.130	140	1.270	Miscellaneous works
Grand total							10^3L.E. 119.800	10^3L.E. 200.200	10^3L.E. 320.000	

Notes:
1. Unit construction costs are based on 1974 commodity price, disregarding any rises from inflation.
2. Bank transfer, earthworks and breakwater extension are to be executed by the Suez Canal Authority or government or public corporations.
3. Foreign currency portion of the cost is required for procurement of materials, equipment and working crafts not available in Egypt and for payment for services to be effected in foreign currency.
4. See Fig. 10-1-1 for division of lots.

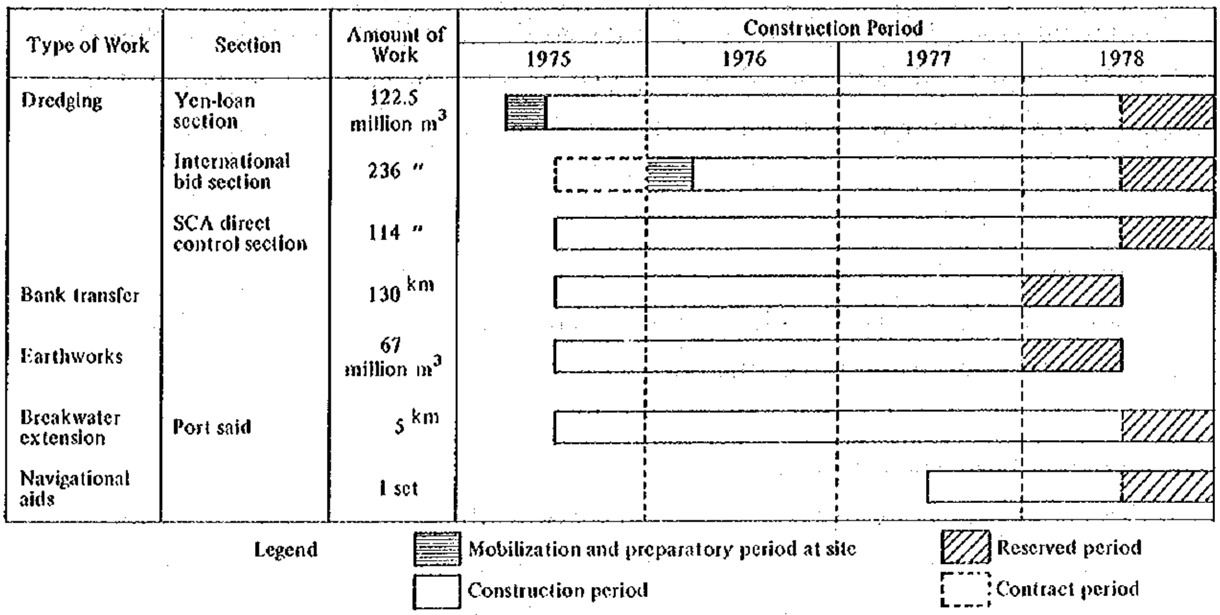


Fig. 10-5-1 Table of Work Schedule

Table 10-5-1 Annual Fund Plan

Unit: L.E. 1 million

Classification	Year	1	2	3	4	Total
Yen-Loan Work	Local Currency	5	7	7	4	23
	Foreign Currency	16	13	13	7	49
	Total	21	20	20	11	72
International Bid Work	Local Currency	–	8	14	7	29
	Foreign Currency	–	40	44	21	105
	Total	–	48	58	28	134
SCA Direct Control Work	Local Currency	2	10	12	6	30
	Foreign Currency	10	8	1	1	20
	Total	12	18	13	7	50
Other Works by Local Contractors	Local Currency	7	15	15	1	38
	Foreign Currency	8	2	2	14	26
	Total	15	17	17	15	64
Total	Local Currency	14	40	48	18	120
	Foreign Currency	34	63	60	43	200
	Total	48	103	108	61	320

Few uncertain factors are expected in the work inside the Canal since its bottom is covered mostly with soft soil. However, a larger safety margin than any other lots should be provided for the exterior lot of Port Tewfik where hard bedrocks are prevalent.

5.2 Annual Fund Plan

Annual requirements of project funds are allocated to each year as indicated in Table 10-5-1 based on the work schedule.

6. Project Management System

The project management system of the Canal Authority is, as indicated in the Canal Authority's Organizational Chart, to have the civil engineering works supervised by Works Department. As agencies under Works Department, there are Branch Offices at Port Said, Ismailia and Port Tewfik, respectively in charge of field work for their own areas.

After orders for work are issued, these Branch Offices will supervise the execution and witness the inspections and surveying. Coordination of working crafts with convoys transiting the Canal is to be made by Transit Department which will directly contact individual working crafts in collaboration with Works Department. The SCA's directly controlled work and maintenance of the Canal are also the responsibilities of Works Department.

The executive and management capabilities of the Canal Authority are high enough for the project because the Authority has often undertaken Canal modification works in the past.

7. Problems Involved in Project Execution

7-1 Ship Manoeuvering

Although the Canal Extension Project is intended to cope with the mammothization of oil tankers, it is likely that the manoeuverability of supertankers will decline markedly in restricted sections of the Canal. In these sections, supertankers will be far less manoeuverable than smaller-sized older tankers.

When the depth, navigable width, profile, and curvature of curved sections of the Canal are reviewed and checked against the theoretical and empirical data, it can be concluded that the project is both reasonable and feasible. However, greater safety of navigation will be assured if consideration is given to the following.

1) Tankers passing through narrow and shallow sections should be instructed to sail along the centre line of the Canal. Any large deviation from the centre line will make manoeuvering difficult due to the unbalance of force and abnormal moment caused by the bank's action. In such a case, use of tugboat is not effective. For this reason, suitable landmarks or signs should be provided near the banks so as to able to measure the deviation accurately.

2) For vessels transiting the Canal, it is necessary to grasp accurately the time required for each vessel to pass the distance between buoys which indicate the course as well as the cruising speed of each vessel.

3) Data of tidal current and changes of tidal range should be obtained.

4) Problems in turning

The turning circle of a larger vessel is almost the same as that of smaller vessels. The circle is slightly small compared with the overall vessel length and a longer time is required before starting the turning. Therefore, when a vessel is sailing at 6 knots, steering must be done at about 900 m before the planned veering point; otherwise, the vessel will swerve greatly. When a vessel sailing at a speed of 6 knots makes accurate steering using the rudder angle in common use, it swerves if the start of steering action is delayed by 30 seconds. The swerving in this case is obtained using the following formula:

$3 \text{ m/sec.} \times 30 \text{ sec.} \times \sin \alpha$

where α is the veering angle.

Therefore, the amount of swerving is as follows depending on the veering angle:

α	15°	30°	45°
Swerving	23 m	45 m	64 m

Thus, it can be concluded that the veering angle of vessels of 150 ~ 200 thousand DWT should be kept at about 30° to allow a swerving of approximately 30 ~ 40 m (width of vessels).

In actual cases, corrections must be made according to the increase/decrease in the rudder angle during veering action, increase of steering effect due to increased engine revolution, and use of a tugboat.

5) When a vessel goes astern, the speed is reduced and a turning movement occurs.

The direction of turning is affected by disturbances and cannot be clearly determined because of the effect of the direction of the turning movement at the start of the engine and angular velocity. The correction of the turning movement will be more effectively performed by the use of a tugboat. This is also necessary to give room for manoeuverability.

6) Management of the waterway

It is of special importance to control the passage of smaller vessels at Port Said and the Port of Suez.

In sum, to meet the future need of passage of supertankers through the Canal, not only an increase in the number of pilots and tugboats but also improvement of pilots' skill to steer giant ships and training of tugboat masters should be considered to ensure safe navigation.

7-2 Work Execution

1) The amount of dredged soil will reach over 200 million m^3 in the international bid section. Therefore, to complete this work in time with the yen-loan section, it is necessary to secure as many as 20 large-size suction dredgers. To give contractors ample time to procure dredgers and to provide a sufficient time allowance to the work itself, early placing of the orders is important for the international bid section.

2) The Suez Canal Authority owns a trailing suction dredger, 6 suction dredgers and 2 bucket dredgers, and it is planning to order for a 8,000-HP suction dredger and to build a trailing suction vessel. SCA intends to dredge approximately 110 million m^3 of soil from the section extending from the 35 km point to the entrance channel of Port Said as well as to start dredging of Port Said by-pass which is included in the second phase project but planned to be undertaken under the first phase project. Dredging capacity will differ depending on the soil condition, depth, distance to the dumping site, weather and marine conditions, the level of the skill in dredging operation, etc. According to the team's estimate, S.C.A.'s amount of dredging seems to be too large for its capacity. Therefore, it will be necessary to accelerate the repair of war damaged working crafts, reexamine the capacity of S.C.A.'s own fleet of working crafts, map out a more suitable program, and invite an international tender for the rest of work. Also, in strengthening its fleet, S.C.A. should take into consideration the fleet system in the wake of completion of the project.

3) Bank transfer and earthworks have a close relationship with dredging of the portion to be widened. When the former lags behind, the latter will be hindered. When the former advances too fast, the present water depth may not be maintained because of slope failure. These three types of work will be performed by different contractors and many dredgers and working sites will be involved. So, for smooth flow of work, an appropriate coordination among these three types is essential.

4) At the peak period of work, more than 30 dredgers will be engaged in all sections of the Canal. Most dredgers are suction dredgers, and when they are being operated not only in lots where the depth is to be increased but in lots where the width is to be expanded, swing wires will be stretched across the Canal and this will be an obstacle to cruising vessels. Therefore, when a convoy passes the Canal, working crafts should retreat to either side of the Canal and swing wires be loosened and lowered until they touch the bottom of the Canal. For this purpose, a wireless communication network should be provided to order each working fleet to retreat. Also, a system should be established to give suitable instructions to secure safety navigation without reducing working hours of fleets too excess.

5) The Canal widening and deepening work in the course south of Port Tewfik should be given a careful technical examination because it will be carried out in the outer sea area with hard layers. First of all a detailed soil survey must be conducted. From the results of the survey, the workable range of suction dredgers will be grasped. If there is any portion where suction dredgers cannot be used, a blasting plan should be prepared for the portion. Also, because there are a lot of uncertainties in this area such as soil conditions, weather and marine conditions, contracts should be concluded under reasonable conditions to avoid giving too great risks to contractors. By so doing, troubles will be considerably reduced in connection with contractors.

6) Even after the Canal is cleared, there is possibility that mines and other explosives remain in the slopes or berms of the Canal. In the execution of the work, prior surveys and other necessary safety measures should be executed to prevent accidents from these explosives. Once an accident of this kind occurs, the crew of working crafts will become so nervous that the whole work may be suspended and therefore, the execution schedule may be delayed.

XI. PLAN OF MAINTENANCE AND MANAGEMENT

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1. Maintenance and Repair of Fairway

1-1 Estimate of Amount of Siltation

Maintenance dredging carries the heaviest weight in the maintenance and repair of fairways.

Here, the maintenance dredging volume needed after completion of the first phase project is estimated for canal waterways and the entrance channel at Port Said.

1-1-1 Maintenance Dredging Volume in Canal Waterway

According to a SCA's report, the maximum accumulation of silt in the Canal is 5 cm/year. This silting seems to be caused by sand blown away from the neighboring desert. Therefore, silting phenomenon will occur in areas extending about 120 km from 40 km to 160 km points not including the Lake Menzala area.

In the waterways in this section, the width of the fairway varies and there are by-passes in some places. But roughly speaking the width of the fairway in this section is considered to be 255 m, the typical cross-section of the Canal.

Accumulation of silt is reported to be 5 cm/year at a maximum but considering actual amounts of accumulation in the past, average figure is estimated at about 60% of this. Thus a rough estimate of accumulation in the Canal amounts to 900,000 m^3/year.

However, this figure is only an annual average. In an actual case, maintenance dredging will be conducted every few years during which the most suitable amount for dredging work is deposited.

1-1-2 Maintenance Dredging Volume in the Entrance Channel of Port Said

In the First Phase Extension Project, the water depth will be made 19.5 m. At the same time the sand-proof submerged breakwater will be extended by about 5 km to prevent the fairway from being silted up. Therefore, any great amount of maintenance dredging will not be necessary. In the Port Said fairway some 3 million m^3 per year will be enough as the maintenance dredging volume during the First Phase Extension Project.

1-1-3 Hydraulic Study of Littoral Drift at Port Said Entrance

The problem of littoral drift at the Port Said Entrance has become increasingly grave as the water depth of the Canal has grown greater.

Fine sand carried by the Nile is found in this area. Average sand size ranges from 100 ~ 150 μ and some can be more suitably called 'particle soil' rather than 'sand.'

Soil characteristics

d_{50} = 150

d_{90} = 500

Shore slope

1 : 300 up to 6 m water depth

1 : 1,300 from 6 m to deeper water

So far it is known that 1 ~ 1.5 million m^3 of silt flows into the fairway annually.

In February 1916 when the water depth was 11 m, a violent storm carried 4 million m^3 of silt into the fairway. It was then that the construction of the present west breakwater was planned. However, since sand kept on depositing continuously along the breakwater and the breakwater itself, which is of a semi-permenble type, settled gradually, 1 ~ 1.5 million m^3 of siltation still occurs today.

In case of a storm, wind and waves come from northwest to west. It is reported that in such a case the height of waves reaches 4 ~ 5 m and their period is 6 ~ 7 seconds. Since waves undergo transformation at the beach, a detailed study is needed to know what breakers are formed at the wave breaking point. Therefore, the rough relationship between wave breaking and sand drift is studied here.

As shown in the conceptual map of the vicinity of the Port Said harbor, sand drift moves from west to east. The sand drift can be classified by the types of its transport as follows:

a) One moving zigzag along the beachline;
b) One carried by the littoral breaker current;
c) One moving along the bed together with sand ripples off shore; and
d) One composed of fine particles, which floats up in sea water and is transported as turbid mass of water.

Since the particle size of the sand drift in this area is very small, all of the above types are considered to join the littoral drift phenomenon. When waves collide with the breakwater or the submerged dike and go beyond them, a considerable amount of sand may be carried by the waves and flow into the waterway.

As for current, a littoral current is produced around the wave breaking point and its direction may change along the breakwater toward the offing. Fine sand particles floating in the current will be carried up to the point near the fairway where the breaker current is weak, passing the head of the submerged wire, and deposit there.

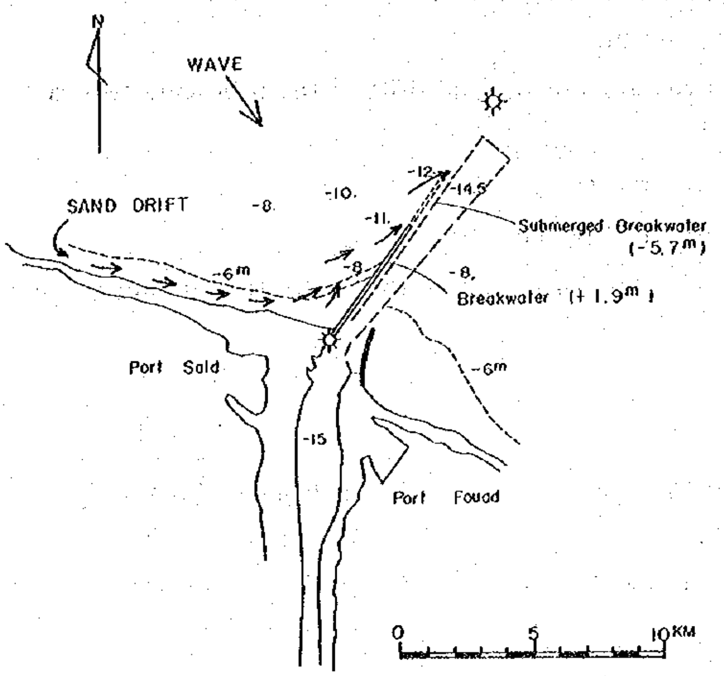


Fig. 11-1-1 Conceptual Map of Sand Drift Movement in the Vicinity of Port Said

The amount of sand drift can be estimated using littoral energy of waves. Savage, Aono & Sato, Sato & Takana and Manohar used the following formula.

$$Q_x = \alpha E_i^n$$

where Q_x is the amount of sand drift in the beachline direction, E_i is the energy of waves and α and n are constants.

Sawaragi & Iwagaki used the following formula:

$$Q_x = 673M \cdot N (\sin 2\alpha_b)^{4/3} \cos \alpha_b$$

where $M = i^{4/3} \times d^{-1/2}$,

$N = H_b{}^3 (H_b/L_o)^{2/3}$,

Q_x is m^3/h

M represents the beach characteristics,

N represents characteristics of incident waves,

i is an average beach slope from the wave breaking point to the beachline (approx. 0.1 ~ 0.5)

d is d_{50} at the beachline,

α_b is the wave breaking angle,

L_0 is the deepwater wave length, and

H_b is the breaker height.

Now let's compute the amount of sand drift in the following two cases using the above formula:

Case 1. $H_b = 4$ m; $T = 6$ sec.

Case 2. $H_b = 7$ m; $T = 11$ sec.

Let's suppose that the wave breaking angle is 45° where the amount of sand drift becomes greatest.

Case 1	Case 2
$M = 0.1^{4/3}/(150 \times 10^{-6})^{1/2} \fallingdotseq 4$ $N = 4^3\ (4/56)^{2/3} \fallingdotseq 11$ $Q_x = 673 \times 4 \times 11 \times \sin(2 \times 45°) \cos 45°$ $\fallingdotseq 21{,}000\ m^3/hr$	$M = 0.1^{4/3}/(150 \times 10^{-6})^{1/2} \fallingdotseq 4$ $N = 7^3\ (7/180)^{2/3} \fallingdotseq 40$ $Q_x = 673 \times 4 \times 40 \times \sin(2 \times 45°) \cos 45°$ $\fallingdotseq 76{,}000\ m^3/hr$

Assuming that the storm continues two full days,

Case 1 .... $Q_x = 1.0$ million m^3

Case 2 .... $Q_x = 3.6$ million m^3

And if the storm continues four full days during which the wave in Case 1 continues for two days and that in Case 2 for another two days.

$Q_x = 5.6$ million m^3

Therefore, 5.6 million m^3 of sand will move in the beachline direction. The sand accumulates on the base of the breakwater and helps extend the beach. Thus the land advances toward the breakwater head. Part of the sand flows over the breakwater or passes round its head, and flows into the fairway.

To eliminate the sand drift completely, there are only two alternatives: further extension of the breakwater to the point where the water depth is large, or removal of the sand drift to the east side beach.

The most economical method may be the removal of the sand in the vicinity of the harbor entrance on a regular basis to always allow a certain water depth. And another effective strategy is to provide jetties at several suitable points beginning from Damietta to prevent the sand from reaching the breakwater of the harbor entrance.

Fig. 11-1-2 shows the relationship between the height above the seabed and the amount of suspended sediment.

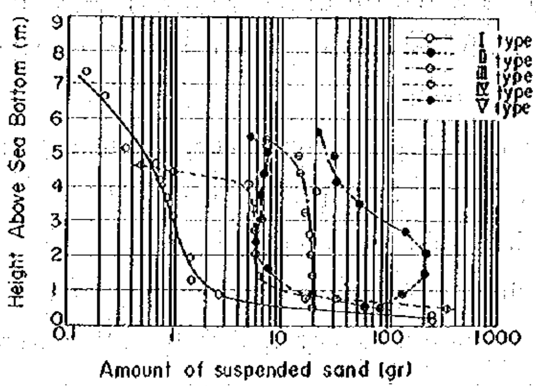


Fig. 11-1-2 Perpendicular Distribution of Suspended Sediments

This figure was prepared by Fukushima & Takemura using the results of their observations. They classified the relationship into the following five types:

Type I: Commonly observed at a natural beach.

Type II: Seen at the corner with a solid angle formed by a projected structure from the beach.

Type III: Seen in the downstream of waves near a breakwater.

Type IV: Not very often observed but seen in areas where the particle size of sand is very minute.

Type V: Observed around a river mouth.

In the case of Port Said, Type I is seen at areas far from the breakwater. Type II becomes gradually apparent as the place becomes closer to the breakwater. Therefore, comparing with other types, the amount of suspended sediment may be much greater.

In case the current along the breakwater is very fast during the storm, it may be a simple but effective method to curve the head of the breakwater slightly outward from the fairway so as to direct the current to the opposite side of the fairway.

When the deepening work of the fairway is completed, this problem will be very important. Sufficient study should therefore be made on this issue.

1-2 Measures against Erosion of Revetment

Since its opening in 1869, the Canal has had to be dredged regularly to maintain a safe fairway for passing vessels. When a vessel passes through the Canal, it produces whirlpools which give damages to the bank. Materials thus washed out pile up on the canal bed and make the fairway shallower bit by bit.

Together with improvements of the Canal itself, work has been continued to strengthen the revetment. The revetment has been step by step constructed and improved since 1876. Especially the east revetment has been gradually moved to the east each time the Canal was widened.

Since its structure is described in other places of this report, this section deals with the relationships between the size and speed of vessels and the fatigue and destruction of the revetment from a hydraulic viewpoint.

When passing through a narrow waterway like the Canal, a vessel produces wave and currents opposite to the vessel advancing direction, the latter being created by water mass pushed by the vessel. Also, because the propagation velocity of long wave in the waterway is expressed by $\sqrt{gh}$ (where h is the water depth and g is the gravitational acceleration), resistance increases sharply as the speed of the vessel (v) becomes close to $\sqrt{gh}$.

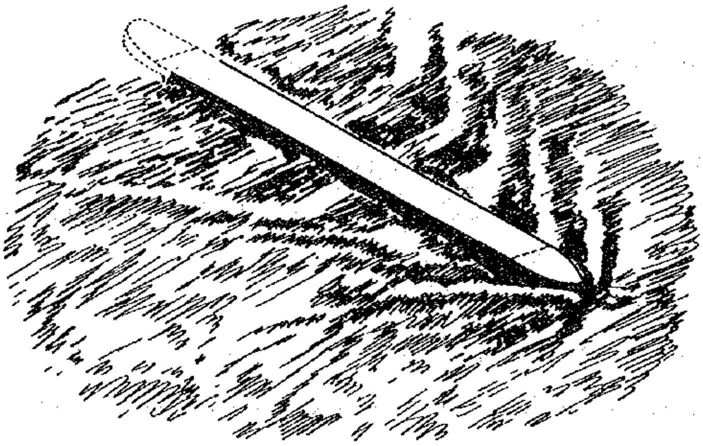


Fig. 11-1-3 Shipwave Created by a Vessel

Also, the ratio of the wet area of the vessel (a) to the cross-section of the Canal water (A) has a close relationship with this resistance.

As regards shipwave, smaller vessels navigating at a great speed may give heavier damages to the revetment than larger ships which navigate at a slower speed.

First, let's consider larger vessels. As larger ships have a greater wet sectional area, they meet with a great resistance in a narrow waterway and are subject to a limiting velocity beyond which they cannot advance (V_L). According to the study of Schijf of the Netherlands, V_L takes the values shown in Fig. 11-1-4.

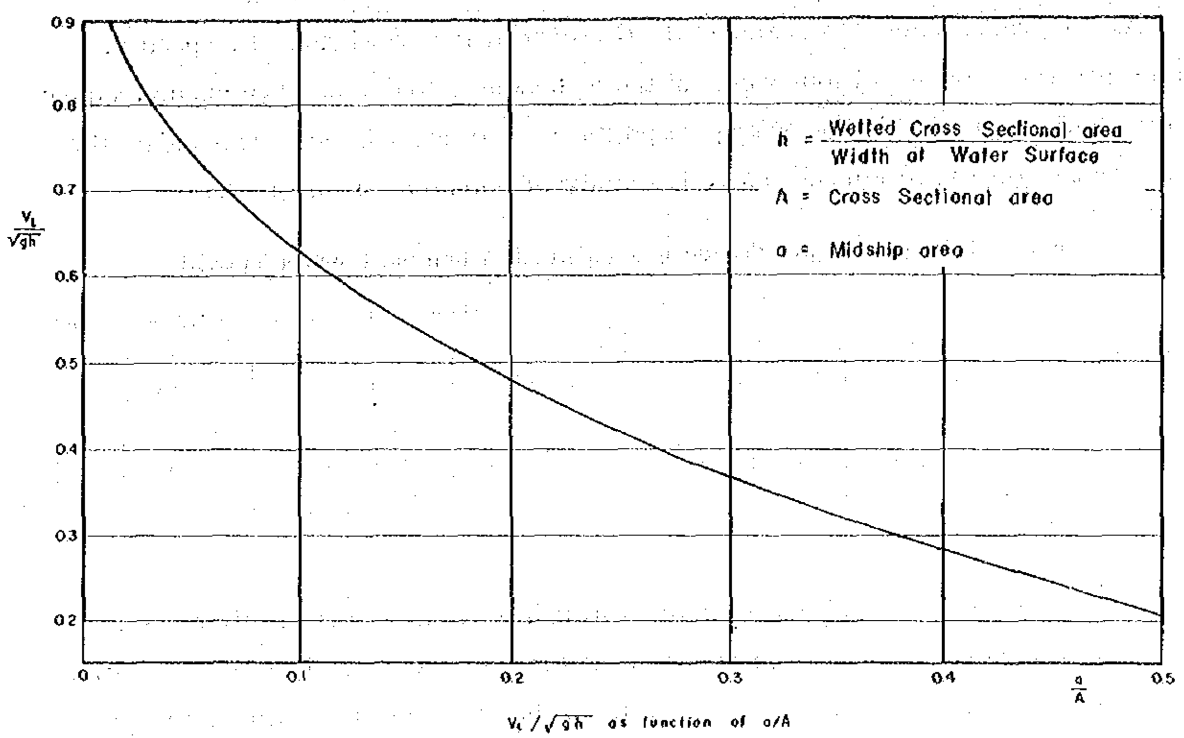


Fig. 11-1-4 Schijf Limiting Velocity

Values of the limiting velocity and the maximum feasible velocity (80% of the limiting velocity) obtained using the ratio of wet area, a/A, are shown in Table 11-1-1.

Table 11-1-1 Limiting Velocity and Maximum Feasible Velocity

(Unit: km/h)

a/A	$V_L/\sqrt{gh}$ *	V_L			
		h = 10 m	h = 12 m	h = 14 m	h = 16 m
0.2	0.48	13.7 (17.1)	15.0 (18.7)	16.2 (20.3)	21.7 (27.1)
0.25	0.42	12.0 (15.0)	13.0 (16.3)	16.1 (20.1)	19.0 (23.7)
0.3	0.37	10.6 (13.2)	12.6 (15.7)	14.6 (18.3)	16.7 (20.9)
0.35	0.31	8.9 (11.1)	10.5 (13.1)	12.2 (15.3)	14.0 (17.5)

* From Fig. 11-1-5
h = Depth of the Canal.
Figures in the parentheses are theoretical values.

Thus, even a tanker which can navigate at 16 knots (28.8 km/h) on the open sea will find it difficult to navigate at 10 knots (18 km/h) in the Canal with its engine at full load. If a/A is 0.25 and the hydraulic depth is 14 m, the vessel's limiting velocity is 8.9 knots (16.1 km/h) and this value can be obtained by an experiment.

As for smaller ships, a/A is almost 0. However, if the vessel runs at a speed near the propagation velocity of long waves in the waterway, a hydraulic phenomenon similar to resonance occurs and waves overlap to produce a very great height. This incurs the worst damage on the revetment (There is a study of Sorensen on this matter).

Table 11-1-2 Vessel Speed Producing Sympathetic Vibrations (Smaller Vessels)

(Unit: km/h; in the parentheses, knot)

Hydraulic depth	10 m	12 m	14 m	16 m	18 m
Vessel speed	35.6 (19.8)	39.0 (21.7)	42.2 (23.4)	45.0 (25.0)	47.9 (26.6)

When a large-size ship advances striving through water mass ahead, difference in water level is created between front and back of the ship. As a result, returning current appears which heads for the direction opposite to the ship's advancing direction. The speed of the opposite current (u) has the relationship shown Fig. 11-1-5 with $u/\sqrt{gh}$. The velocity of the current (u) has the values shown Table 11-1-3 when a/A is 0.25.

Table 11-1-3 Values of Returning Currents

(Unit: m/sec)

$v/\sqrt{gh}$	Hydraulic Depth / $u/\sqrt{gh}$	10 m	12 m	14 m	16 m	18 m	20 m
0.24	0.09	0.89	0.98	1.05	1.13	1.20	1.26
0.27	0.10	0.99	1.08	1.17	1.25	1.33	1.40
0.30	0.13	1.29	1.41	1.52	1.63	1.73	1.82
0.33	0.15	1.49	1.63	1.76	1.88	2.00	2.10
0.36	0.18	1.78	1.94	2.11	2.25	2.39	2.52

(a/A = 0.25)

These values cause bedload drift of materials of the northern part of the Canal where the soil size ranges from 100 to 150, and are also liable to invite erosion of the revetment. Therefore, the cross-section of the Canal should have a sufficient area and the vessel velocity should be reduced to a suitable level.

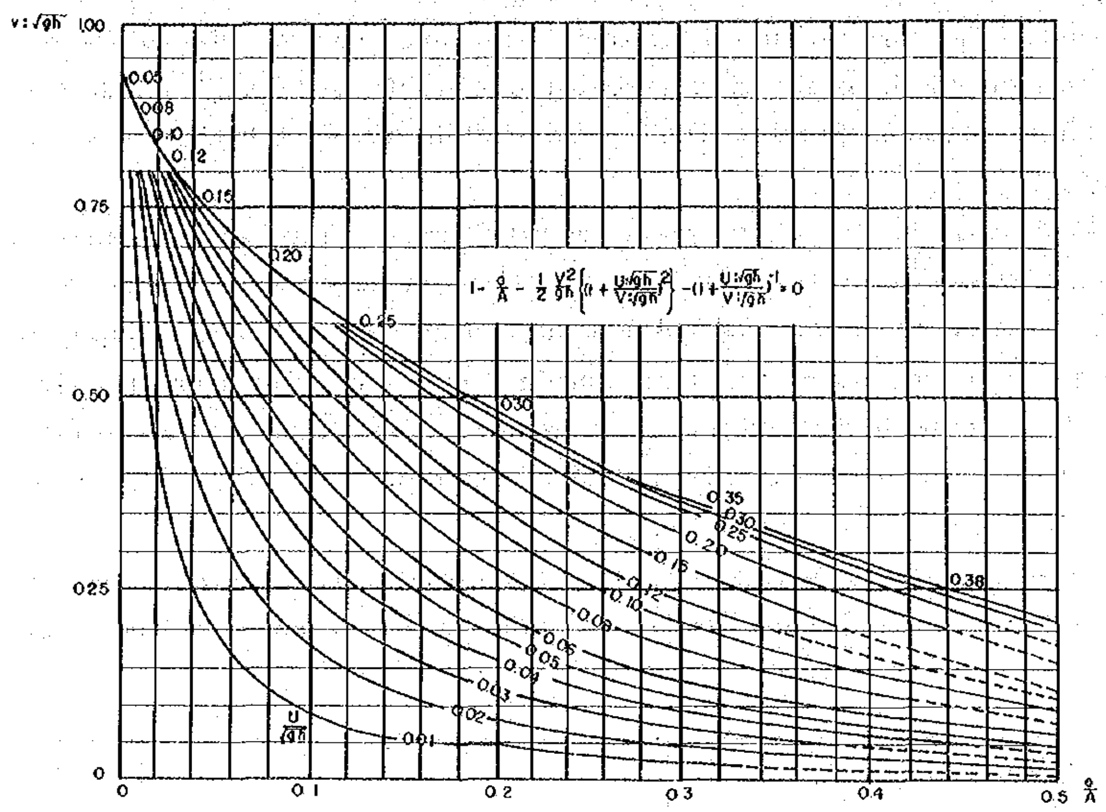


Fig. 11-1-5 Lines of Constant Values u : $\sqrt{gh}$ as Function of a : A and v : $\sqrt{gh}$

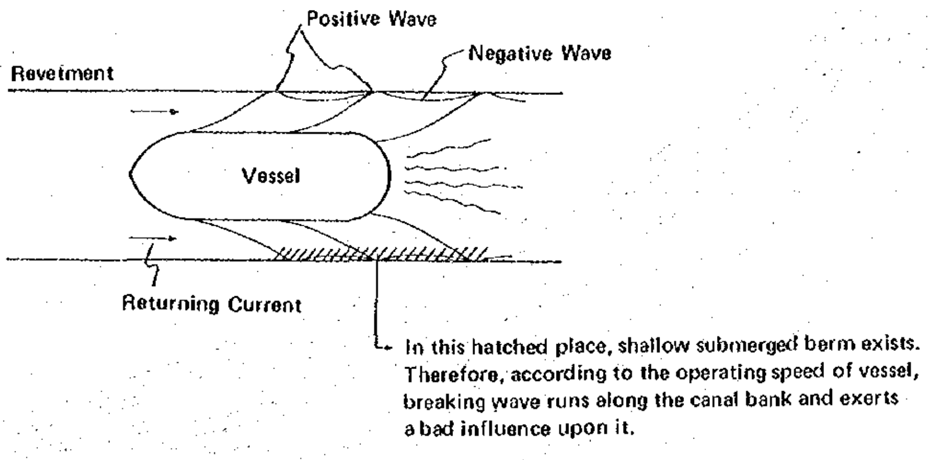


Fig. 11-1-6 Conceptual Map of Returning Current

Let's suppose that the water depth is 18 m and $v/\sqrt{gh}$ is 0.36. Because v = 17.2 km/h, if the vessel navigates at 9.6 knots, the returning current will reach 2.4 m/sec. When the velocity of the vessel is reduced to 6.5 knots or 11.7 km/h, $v/\sqrt{gh}$ becomes 0.24. According to Fig. 11-1-5, it is estimated that $u/\sqrt{gh}$ is 0.09 and u is 1.2 m/sec.

As discussed thus far, in areas where the particle size of soil is minute, speed reduction or cross-section enlargement is a key problem. In areas where tidal currents prevail, it is assumed that the tidal and returning currents react each other, reducing or increasing the adverse effect. Fortunately, however, in the case of the Canal, particle size of bed materials in the southern part where there are strong tidal currents is comparatively large, and the limiting flow velocity of movement in the area is great. Therefore, this problem will not be very severe.

Another problem is the backwashes that vessels create. The height of backwashes is either higher ('crest') or lower ('trough') than the mean water level and observations

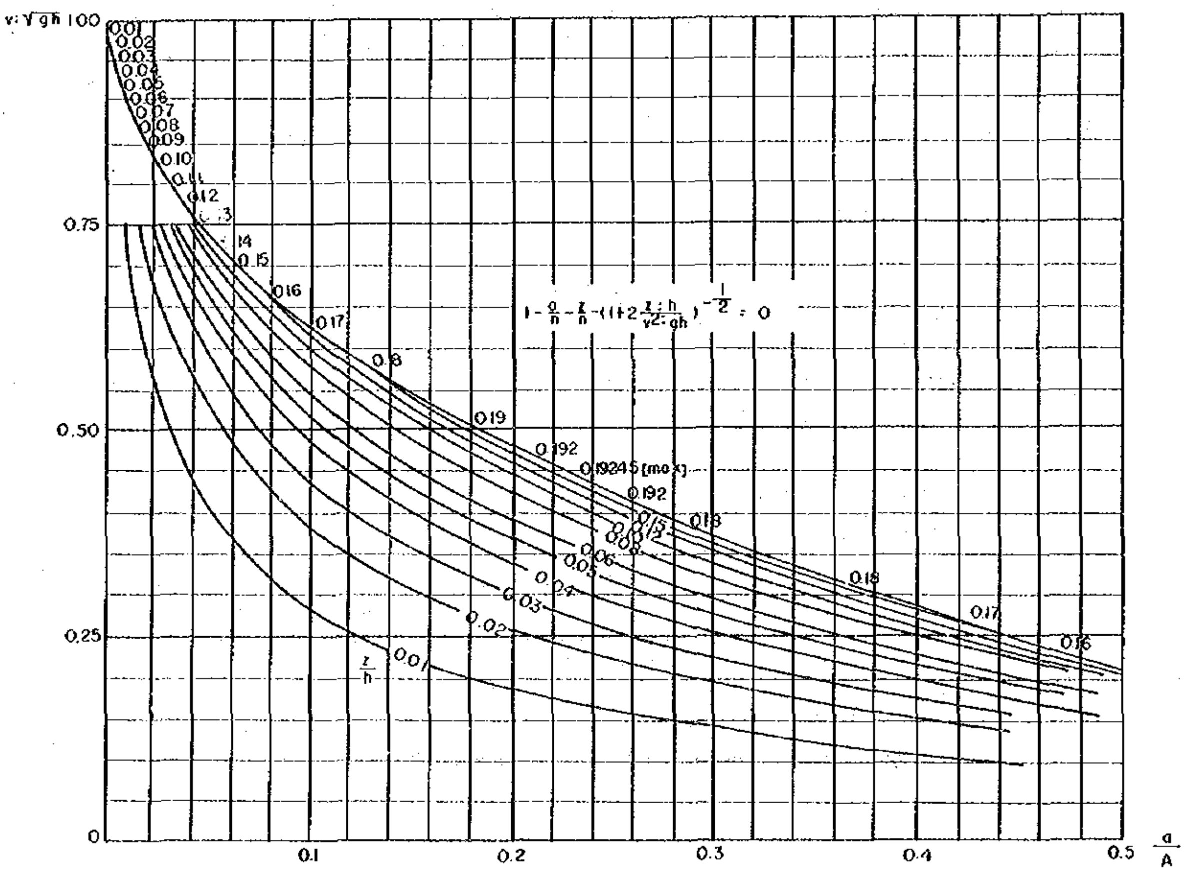


Fig. 11-1-7 Lines of Constant Values z : h as Function of a : A and v : $\sqrt{gh}$

indicate that the 'trough' is three times greater. This 'trough' of backwashes may remove sand of the revetment. The height of backwashes (z) has been obtained both theoretically and empirically as shown in Fig. 11-1-7.

Using this figure and giving specific values to a/A and $v/\sqrt{gh}$, values of z/h can be found (See Table 11-1-4).

Table 11-1-4 Wave Height of Backwashes (a/A = 0.25)

(Unit: m/sec)

$v/\sqrt{gh}$ \ Hydraulic Depth	10 m	12 m	14 m	16 m	18 m	20 m
0.24	25	30	35	40	45	50
0.27	34	41	48	54	61	68
0.30	44	53	62	70	79	88
0.33	58	70	81	93	104	116
0.36	75	90	105	120	135	150

When the safety factor of wave height of 2.5 which was proposed at the International Navigation Congress (hereinafter referred to as 'INC') is adopted, and supposing that the maximum erosion is 2 m, the wave height should be kept at 80 cm or less.

There is another simpler formula to find the values of z proposed by a Russian scientist.

$$Z = \frac{V^2}{2g} \cdot \frac{2(A/a) - 1}{(A/a) - 1}$$

The value of Z can also be obtained from the following formula which was empirically established on the strength of the past Canal operation.

$$Z = \frac{V^2}{2g} \cdot \frac{2(A/a) - 1}{(A/a - 1)^{3/2}}$$

If the maximum scouring length in Fig. 11-1-8 is taken at 2 m or half of the sheet pile length and the safety factor at 2.5, Z ≦ 80 cm. By applying the above formula,

$$0.8 = \frac{V^2}{2g} \cdot \frac{2 \times 4 - 1}{(4 - 1)^{3/2}} = \frac{V^2}{19.6} \cdot \frac{7}{\sqrt{27}}$$

$$V^2 = 0.8 \times 1.96 \times \sqrt{27}/7 = 11.65$$

$$V = 3.41 \text{ m/sec.} = 12.3 \text{ km/h}$$

This speed is too slow and indicates that adequate erosion-preventive measures should be taken in future if a cruising speed of 14 ~ 15 km/h is to be maintained.

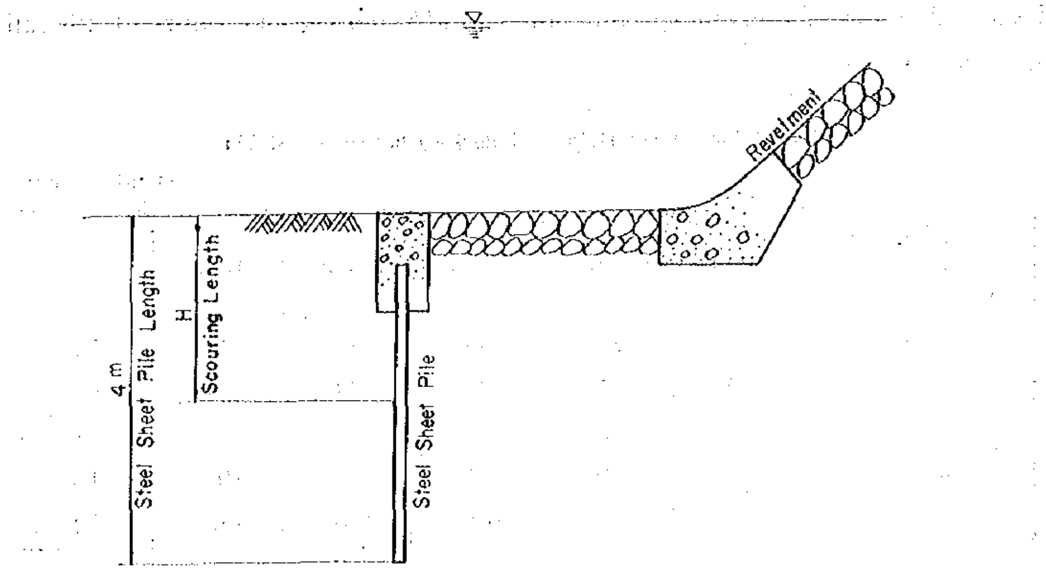


Fig. 11-1-8 New Revetment and Scouring Length

When passing through a narrow waterway, large vessels should reduce their sailing velocity as much as possible both to keep safety and to protect the revetment. In reality, however, convoys composed of a variety of vessels pass and many small vessels navigate at a higher speed than large ships. Considering this fact, full consideration should be given to the fatigue of the revetment.

At its Rome and Cairo meetings, the INC concluded that the fatigue of revetment may be calculated using an average type of vessels. In the case of the Suez Canal, the average of supertankers and mammoth tankers is adopted.

Because the Suez Canal has as long as 260 km extension of revetment, it costs a huge amount of expense and time to repair. Therefore, it is imperative to establish low-cost but effective erosion-preventive measures on the basis of careful research activities.

Further study will have to be made on the fatigue phenomena of structures including removal of sand and erosion for the planned bank transfer for 130 km.

To check the degree of fatigue of the revetment, the repeated load method should be used as in the fatigue tests of structures.

Computer simulation analysis should be adopted by the parameters of suitable class, number and speed of vessels, which are considered as the repeated average loads. These results should be reflected on the design of the revetment to be moved to the east.

Table 11-1-5 shows maximum feasible velocity, backwash height and returning current at the reopening of the Canal, upon completion of the first phase project and upon completion of the second phase project.

Table 11-1-5 Maximum Feasible Velocity of Ordinary Vessels (80% of Theoretical Values)

	At Reopening of the Canal	On Completion of 1st Phase Project	On Completion of 2nd Phase Project
Wet cross-section (A): m	1,800	3,275	4,260*1
Width of Canal water surface b_s: m	170	240	245
Bottom width of the Canal (wetted perimeter): m	173	258	279
Water depth of the Canal: T	15.0	19.5	23.5
Hydraulic depth of the Canal: h	10.7	12.8	15.4
Largest navigable vessel: DWT	60,000	150,000	250,000
Draft: ft (m)	40 (12.2)	53 (16.1)	67 (20.4)
Width: m	37	49	51
a: m^2	450	800	1,050*2
Maximum feasible velocity: km/h	14.8	16.8	18.4*3

Notes: 1. Values obtained at the 30 km point.
2. a/A is taken at 0.25.
3. 80% of the maximum theoretical values.

As shown in the above table, the limiting velocity increases as the project advances. That is, as the water depth increases the Canal capacity becomes larger.

The distance between buoys indicating the boundary of fairways will be:

On reopening	89 m
After 1st phase project	160 m
After 2nd phase project	190 m

Considering the decline of manoeuverability, it is not necessary to navigate at the maximum speed. Therefore, three speeds, 13, 14 and 15 km/h, were used in calculating the backwashes and returning current. As for backwash height (z), it was obtained using Fig. 11-1-7 and SCA's empirical formula. For safety factor, conventional value of 2.5 is used because no relevant data are available.

If rubbles are refilled in front of the revetment at time of its construction as illustrated at the right, it will prove to be a substantial improvement.

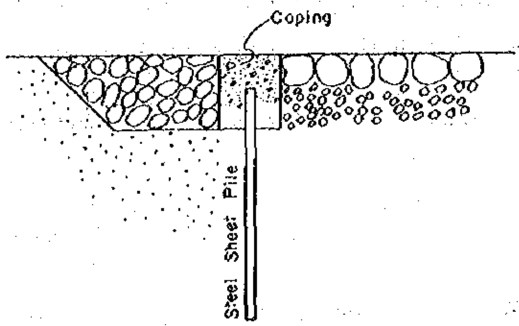


Table 11-1-6 Waves and Returning Currents Produced by Passage of Largest Vessel

Navigation velocity: V_0	u = m/sec z = cm	On reopening	On 1st Phase Project Completion	On 2nd Phase Project Completion
13 km/h	Returning current: u	1.30	1.40	1.40
	z*	40	40	35
	z**	80	80	80
14 km/h	Returning current: u	1.60	1.65	1.50
	z*	55	50	45
	z**	90	90	90
15 km/h	Returning current: u	1.80	1.80	1.70
	z*	65	60	55
	z**	100	100	100
Scheduled largest possible vessel: DWT		60,000	150,000	250,000

* Values obtained from Fig. 11-1-7.
** Values obtained from SCA formula.

Above table shows that the larger the cross-section becomes, the smaller the returning current becomes. The current speed seems to increase some 10% per 1 km/h increase in navigation speed. In areas near Suez where tidal current prevails, tidal current of 1.5 m/sec. should be added at time of the high water in spring and fall. In this case, the erosion of the revetment could occur, so that the speed of largest vessels should be reduced to a minimum. While further study is needed on this matter, observation of tidal current in the area and reinforcement of the bulkhead will become necessary in the future.

Values of backwashes obtained by the two methods differ widely from each other. SCA formula does not consider the effects of water depth and increase in the width and therefore, when the value of a/A is constant, wave height remains the same. Values obtained from the SCA formula is bigger and a wave height of approximately 1 m is expected.

According to a field study conducted in 1966 when the cruising speed was set at 14 km/h, the observed value of z was 90 m. SCA considers this represents the actual condition more closely. However, its validity is uncertain when the cross-section or navigation velocity changes greatly.

It is also necessary to examine whether it is proper to use the conventional safety factor of 2.5, but in any way when the speed is 13 km/h, waves that hit the revetment will be controlled at 80 cm or less.

The revetment should be so constructed that it may resist sand removal and absorb the wave energy as much as possible.

Next, let's consider the values of u and z for transit vessels of the commonest types. For the convenience of computation the following values are assumed for the commonest transit vessels.

	DWT	Wet cross-section	a/A
On reopening	30,000	300 m^2	0.17
After first phase project	100,000	590	0.18
After 2nd phase project	150,000	800	0.19

Table 11-1-7 Returning Current and Backwash Caused by Average Type Vessel in the Canal

Navigation velocity: V_0	u = m/sec z = cm	On reopening	On 1st Phase Project Completion	On 2nd Phase Project Completion
13 km/h	Returning current: u	0.95	0.95	1.00
	z*	40	40	40
	z**	67	67	67
14 km/h	Returning current: u	1.05	1.05	1.10
	z*	50	45	45
	z**	78	78	78
15 km/h	Returning current: u	1.20	1.20	1.20
	z*	55	55	55
	z**	95	95	95
Scheduled largest possible vessel: DWT		30,000	100,000	150,000

* Values obtained from Fig. 11-1-7.
** Values obtained from SCA formula.

Though more detailed analysis may be necessary, it is desirable that the revetment be designed to be free from erosion when subjected to the returning current and backwash whose values are shown above. It would be enough if navigation velocity is set at 14 km/h or less.

Table 11-1-8 shows similar data for small high-speed ships and general liners.

Table 11-1-8 Estimated Values of u and z for Liners and High-Speed Vessels

Type of Vessel	On Reopening	On 1st Phase Project Completion	On 2nd Phase Project Completion
Liner: 15,000 DWT; a = 200 m^2	U = 0.60 m/sec	U = 0.30 m/sec	U = 0.20 m/sec
V = 14 km/h	Z = 50 cm	Z = 42 cm	Z = 40 cm
High-speed vessel 30GT; a = 10 sq.m.			
V = 30 km/h	* Z = 265 cm	* Z = 190 cm	* Z = 155 cm
V = 35 km/h	* Z = 357 cm	* Z = 260 cm	* Z = 210 cm

Note: Values of z are obtained from SCA formula.

* It is considered that these values exceed applicable range of the formula.

There seems to be no significant problem concerning general liners. But formulas for z, particularly that of SCA, seem to exceed the applicable limit. Therefore, it would be simpler and more accurate to measure actual wave heights when small vessel navigate at a high speed.

The above is a hydraulic consideration concerning the countermeasures against revetment erosion. Measures against sand removal and the revetment structure will be discussed in the section treating the structure map and its explanation.

Reference: SCA's report for INC meeting at Paris, 1969 (SII-3)

Concerning areas where tidal currents prevail, following examinations have been conducted.

The average tidal current in the Tewfik – Little Bitter Lake area is estimated at 1.5 m/sec. in spring and fall and 1.0 m/sec. in other seasons. After completion of the first phase project, the tidal current is assumed to increase by 10%. When converting these values to hourly speed, we get

4.0 km/h for normal time

5.9 km/h for high tides in spring and fall seasons. Thus the tidal current will give a considerable amount of influence.

The convoys sailing plan after completion of the first phase project is prepared as follows:

Southward convoy	All vessels	14 km/h
Northward convoy	Tankers 18,000 DWT or less	11 km/h
	Tankers 18,000 ~ 100,000 DWT	10 km/h
	Tankers 100,000 DWT or larger	10 km/h
	General cargo boats	13 km/h

Here, let's examine three cases: loaded large tankers, larger tankers navigating southward, and general cargo boats.

Table 11-1-9 Ground and Relative Speed (Convoy Plan Considering Tidal Currents)

Type of vessel	Ground velocity	Relative speed	
		Against	Follow
Loaded 150,000 DWT tanker	10 km/h	14 (15.9) km/h	6 (14.1) km/h
250,000 DWT tanker in balast	14 km/h	18 (19.9) km/h	10 (18.1) km/h
General cargo boat	14 km/h	18 (19.9) km/h	10 (18.1) km/h

Figures in the parentheses are those for a high tide during spring and fall seasons.

When a vessel navigates in the direction of the tidal current, checking of steerability should also be performed. And if a vessel navigates against the direction of the tidal current, the relationships with the maximum speed v_L should also be considered.

In the former case, if the speed exceeds the values given in the above table, no problem will be raised as to the current or the wave, which is desirable from the viewpoint of steering. Therefore this case is not considered here.

The problem does exist in the latter case. Whether the convoy plan is feasible, and how much the effect on the revetment will be should be examined.

Maximum navigable velocity (80% of the limiting velocity) is as follows:

Loaded 150,000 DWT tanker a/A = 0.25 V_{max} = 16.2 km/h

250,000 DWT tanker in ballast a/A = 0.18 V_{max} = 16.2 km/h

20,000 DWT cargo boat a/A = 0.07 V_{max} = 21.9 km/h

Generally speaking, when a tanker of 250,000 DWT is in ballast and its wet area is around 600 m^2 (10.9 m x 55 m), the design speed cannot be maintained due to the great resistance of water and wind. So, it is desirable to make the speed about 1 ~ 1.5 km/h lower than the design value.

In a high tide during spring or fall seasons, a 250,000 DWT class tanker in ballast will have to navigate southward at a speed about 3 km/h lower than planned, that is, at a ground speed of 11 km/h or preferably 10 km/h considering its maximum speed. In this connection, the following data concerning backwashes and returning currents should be considered together.

Table 11-1-10 Backwashes and Returning Currents at High Tide During Spring and Fall Seasons after Completion of First Phase Project

Vessel	Ground velocity km/h	Relative velocity km/h	a/A	Backwash height: z (cm)		Returning current: u (m/sec)
				(1)	(2)	
Loaded 150,000 DWT tanker	10.0	15.9	0.25	130	130	2.24
250,000 DWT tanker in ballast	10.0	16.8	0.25	200	150	3.08
	(9.0)	(14.9)	(0.18)	(51)	(91)	(1.12)
General cargo boat	10.0	16.8	0.07	19	60	0.45

Notes: (1) By paphic solution.
(2) By SCA's formula.

In this checking it is understood that both backwashes and returning currents exceed their permissible amounts. A 250,000 DWT class tanker in ballast (gas-free) will have to navigate at 10 km/h or less in this section.

Northward Convoys:

A northward 150,000 DWT tanker with load will also have to navigate at 9 km/h and at a relative velocity of 15 km/h. A convoy navigating northward has spare time, so operation can be performed without changing the overall plan.

For this purpose, it is necessary to include gas-free supertankers in convoy No. 1 leaving Port Said. Also, the navigation speed of the convoy between Tewfik and Bitter Lake should be 4 ~ 5 km/h lower than planned. When the speed is reduced from the scheduled 14 km/h to 9 km/h in the 50 km section between Little Bitter Lake and Suez, it takes about 2 hours longer, but this is necessary in a high tide during spring and fall.

Southward Convoys:

According to SAC's plan, the southward convoy No. 1 is scheduled to reach Tewfik some time between 18:00 and 20:00. If this arrival time is delayed to between 20: 00 and 22:00, the purpose will be well achieved without affecting other convoys. But the working hours of tugboats and pilots become longer to create a problem of labor management.

Although there exist several minor problems, it can be concluded from the above discussion that the navigation of convoys can be planned without any grave effect on the revetment.

The Problem of Scouring at By-pass:

One of the erosion problems at the revetment and slope arises at those by-passes where vessels come to anchor temporarily so as to wait for other convoys to pass by.

When a vessel once anchored temporarily opens the engine to its full capacity at a berth along the slope, its screw will wash away sands of the slope. To prevent this, groundsels for sheet pile of the revetment were driven down to -10 m at Ballah by-pass, but it is said that there is a fear of gradual wash-off owing to the scouring of the slope.

There appears no effect of backwash in such place, as the speed of vessels almost equals zero. Sands deposited on the bottom may shallow the water depth of waterways, but because there is no squatting, vessels may scarcely scrub the bottom. This may not cause so much trouble if the bottom is dredged in good time and sands removed or thrown at the foot of revetment.

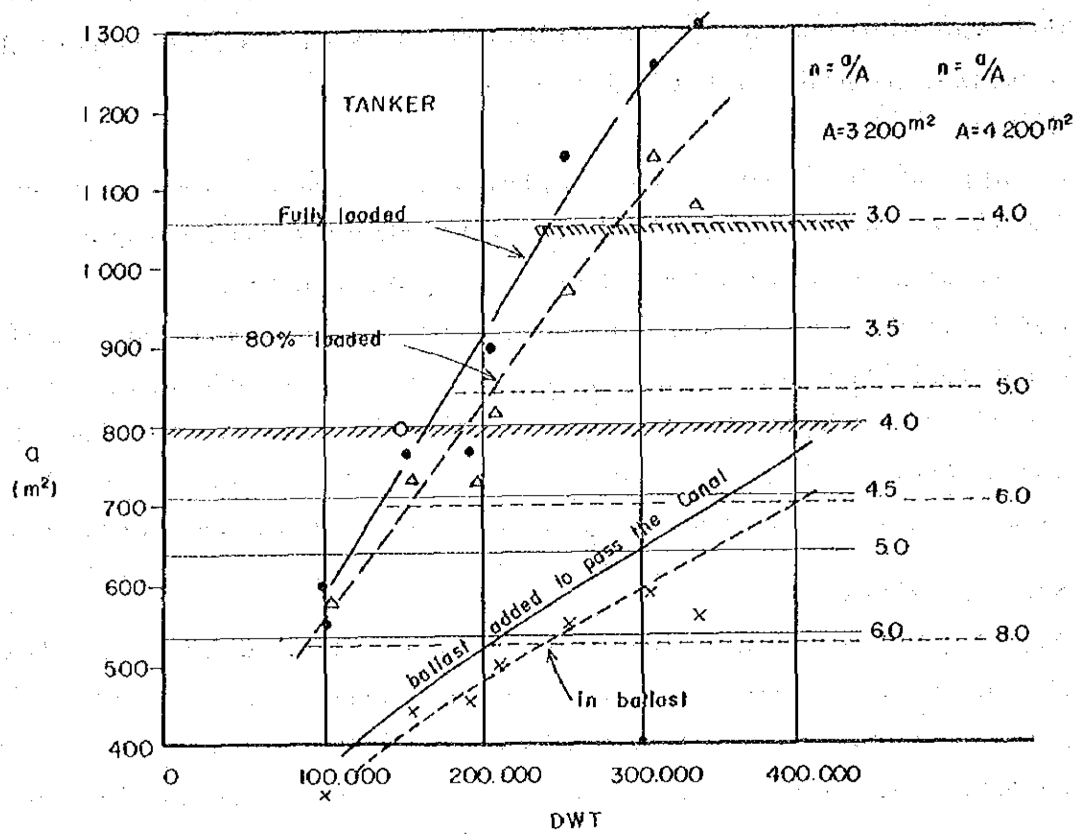
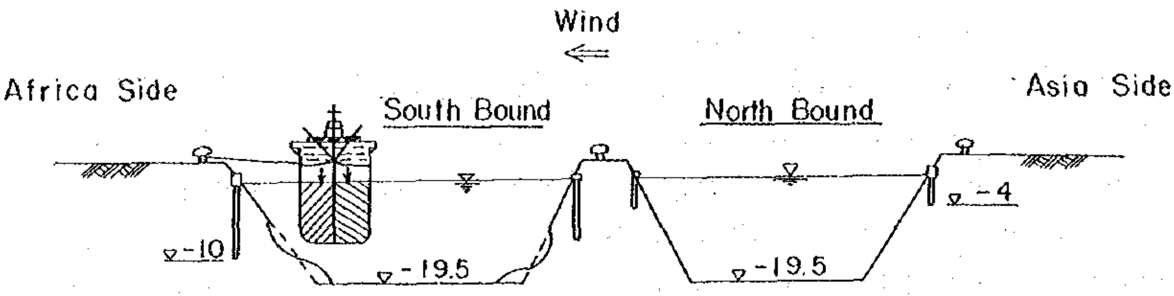


Fig. 11-1-9 Relationships between Wet Cross-section and DWT of Large Tankers



Note: Southbound vessels approach leeward and stop.

Fig. 11-1-10 Sketch of Ballah By-pass

However, since the dredging cost amounts to L.E. 3,000 yearly, it seems that S.C.A. wants to find the way to save this as much as possible.

1-3 Method of Fairway Maintenance

As for the method of maintenance dredging inside the Canal, trailing suction dredgers seem to be suitable when account is taken of the need of avoiding passing vessels and the shallowness of digging depth, etc. However, because of the limits set on the dumping site it will be reasonable to use suction dredgers in sections rather far from the dumping site and trailing suction dredgers in Port Said waterway, and both types around Bitter Lakes and Timsah Lake.

1-4 Maintenance and Repair Cost

Breakdown of the maintenance cost of the Canal, civil engineering facilities and navigation aids stands at roughly L.E. 650 thousand/year for maintenance dredging, L.E. 450 thousand/year for repair of revetment and breakwater, and L.E. 300 thousand/year for maintenance of navigation aids, totalling L.E. 1,400 thousand/year. Depriciation cost for facilities and working craft, however, is not included. Nor are other Canal development plans like the Second-phase Extension Project taken into account.

2. Management and Operation Method

2-1 Canal Management

There appeared no change whatsoever from what had been before the closure in that the Canal is to be managed entirely by the Suez Canal Authority including maintenance and repair.

Members of the technical staff scattered out of the country during the closure are also returning to Egypt in preparation for the reopening, and it seems rather near in future that the pre-closure conditions will be restored. It is judged from the organizational point of view that the management and operation can fairly be carried out by the existing setup.

Basing upon views and opinions presented above, the current management system and organization will be considered to show no sign of problem for the canal management after the expansion. To ensure smoother management and operation in the foreseeable future, however, the following points may need to be studied thoroughly before the first-phase project will be completed.

a. Mammothization and increased transit of tankers will necessitate more tugboats than at the time of reopening, and at the same time it will become needful to secure the requisite personnel for their operation as well as to conduct systematic training and retraining of personnel including pilots in the manoeuvering of large-sized tankers.

b. It is expected that the revenue from the Canal after the expansion will show a sharp increase as compared to that of the reopening period, and accordingly the volume of work for, for instance, repaying the funds raised for the reopening and expansion will also increase remarkably. An organizational strengthening, therefore, will be required for the financial department.

c. A new tariff system will be applied after the Canal reopening. Since the current system cannot be justifiably applied after the Canal extension, it is necessary to make scrupulous studies for establishment of a new tariff system that can be applied after the Canal expansion is completed.

2-2 System of Utilization Charges

Ten years have passed since the transit dues of the Canal were revised last in 1966 to P.T. 43.73/1 SCNRT for loaded ships and P.T. 19.94/1 SCNRT for vessels in ballast. In view of the rise in price on an international basis during the past decade and the financial situation of the SCA on the other hand, a new tariff system will have to be established as a matter of course. It is in line with this idea that the British, Norwegian and Japanese consulting firms are currently conducting research works on establishing a new tariff system entrusted by the SCA, and the conclusion is expected to be given before long.

Before the closure most of the sea-borne traffic between the east and the west of the Suez Canal was made available through the Canal, but it is the tendency at present that an increasing number of supertankers take the course via Cape Town. In addition, with the recent surplus tonnage of tankers the rate-fixing for tankers became a very difficult problem, and therefore will be finalized after various factors other than the rise in price are taken into account.

In any case, however, the new system is supposed to go over the current rate level and as such will enrich the finances of the SCA.

For reference, revenue from the Canal as estimated on the basis of current rate system is shown in Table 11-2-1. As for annual revenues, see section 1-2 (Benefit) of Chapter XII (Study on Economic Feasibility)

Table 11-2-1 Revenue from the Canal (Million L.E.)

	1965/7 ~ 1966/6	1975	1980	1985
1. Re – opening				
1) Dry Cargo		52.7	68.0	88.4
2) Oil		33.9	17.8	26.4
a. S/S		(22.9)	(11.0)	(18.0)
b. C/S		(11.0)	(6.8)	(8.4)
3) Total		86.6	85.8	114.8
2. 1 st Stage Plan				
1) Dry Cargo			68.0	88.4
2) Oil			64.5	82.0
a. S/S			(55.5)	(70.5)
b. C/S			(9.0)	(11.5)
3) Total	91.3		132.5	170.4
3. Difference between 1& 2			46.7	55.6

The above table shows that the level prior to the closure can only be recovered after the year 1980 by mere reopening of the Canal; but if by Canal expansion, 50% increase in revenue can be expected comparing to the case of mere reopening.

2-3 Management and Operation Cost

According to the 1964 ~ 1967 results, the management and operation cost consists of general management expenses, operation expenses for the Canal and Port Said, facilities maintenance expenses and public utilities expenses, and accounts for approximately 8% of the total revenue from the Canal. Since it is judged right to assume that this percentage may not change even in the years to come, the future management and operation cost will be estimated, employing this percentage, at L.E. 8.9 million in 1965/7 ~ 1966/6 while it will rise to as high as L.E. 10.6 million in 1980 and L.E. 13.6 million in 1985. Annual management and operation cost is shown in Table 12-2-4. (Note that the management and operation cost in this case is 1/2 of the total amount for reasons given in Section 1-1 of Chapter XII.)

XII. STUDY OF ECONOMIC FEASIBILITY

XII. STUDY OF ECONOMIC FEASIBILITY

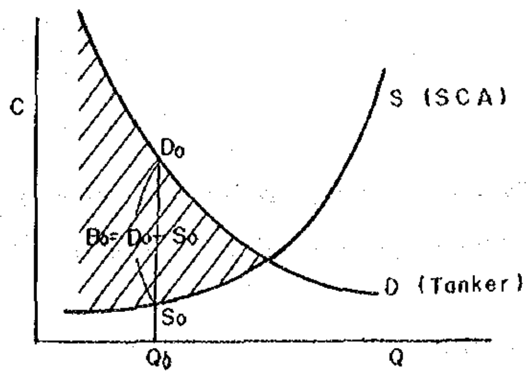
1. National Economic Evaluation

Effects of the expansion of the Suez Canal can broadly be divided into two. First one is pointed out to be an impact on the Egyptian economy. In other words, an increase in the revenue from the Canal when expanded will contribute to the progress of Egyptian economy in the shape of an increase in the gold and foreign exchange reserves. The second is that the cut-down of transportation cost of crude oil will be made possible through expansion, since those supertankers that used to pass by way of Cape Town previously will be able to utilize the Suez Canal. This directly leads to the benefits of tanker-owners or shippers and indirectly to those of people in the world. Therefore, evaluation may be made from the standpoints of:

1) People of Egypt;
2) Tanker-owners or shippers;
3) Both of above 1) and 2).

However, the team is in the opinion that the evaluation should be made from the standpoint of 1) above, as the project is to be financed by a Japanese loan.

Benefits of the Canal expansion, when illustrated in a supply-demand curve as shown on the right, coincide with $D_0 - S_0$ ($=B_0$) corresponding to Q_0 in the hatched area. SCA and tanker-owners are going to share the benefits in this hatched portion. Therefore, if the evaluation results of 1) are satisfactory, so will be those of 3)



Method of IRR (Internal Rate of Return) was adopted for the evaluation and the project life was estimated at 30 years after completion of first phase extension project.

The local currency of Egypt is not always stable and there seems to be a difference between the official and actual exchange rates. For foreigners staying in Egypt for a short time, the government permits the application of the traveller's rate which is different from the official exchange rate. It may therefore seem necessary to introduce the idea of shadow price in the economic evaluation. In the case of this project, however all the benefits are supposed to be paid in foreign currency while local currency is included in costs. Hence, the concept of shadow price was not adopted, as it was judged safer for the evaluation not to introduce it.

1-1 Costs

Costs are composed of construction cost and maintenance and management cost, and are naturally limited to those required for the first phase project. That is to say, only the construction cost of the first phase project is considered, and if materials of existing facilities are available for the first phase project, only the removal cost is listed up. As for the maintenance and management cost, 1/2 of the total maintenance and management cost for the Canal as a whole is specified because of the technical difficulty is summing up the costs required for the first phase project.

Items of construction cost and maintenance and managemnet cost are as follows. Annual construction cost is based upon the plan of execution. For details refer to section 4 (Construction Cost) of Chapter X (Plan of Execution).

Construction Cost: Dredging, Overland Earthwork, Revetment, Breakwater, Navigation Aids (Commodity tax on materials included).

Maintenance & Management Cost: Maintenance Dredging (Refer to section 1-4, Chap. XI), Other Maintenance & Management (General Management, Operation, Facilities Maintenance, and Others).

Other Maintenance & Management Expenses = Yearly Revenue from the Canal x 0.08 (Actual proceed in 1965) x 1/2

1-2 Benefits

The increase in the revenue from the Canal after the first phase project (total revenue – revenue after reopening) was listed up as benefits.

The estimation of the revenue from the Canal was based on the current toll system. It is not reasonable to apply the current toll system because of the rise in prices since the closure of the Canal. However, although various foreign consulting teams are now studying, entrusted by SCA, on how the new system should be, its results are late in coming out for inclusion in this report. The team was therefore obliged to adopt the current system report. Since the toll under the new system will be naturally higher than at present, S.C.A.'s revenue will increase further. Accordingly, adoption of the current system will cause no serious problem for evaluating the project.

The current system is designed to collect transit dues at a rate of 43.73 P.T./1 SCNRT (Suez Canal Net Registered Ton.....see VI. Suez Canal Authority) while a low rate of L.E. 19.94/1 SCNRT is fixed for tankers in ballast.

The estimation of benefits on the basis of this toll system is shown in Table 12-1-1 which indicates that a benefit of L.E. 16.4 hundred million (Base year: 1975) will be produced during 30 years of the project life. As for the revenue from tankers, however, it is assumed that there will be no increase after 1985, so that the 1985 figure is shown for all subsequent years.

While benefits from tankers alone are considered here. it is expected that ore carriers of more than 60,000 DWT will enjoy the merit of expansion and will contribute to an increase in the revenue of S.C.A. However, benefits from ore carriers were excluded from the estimation because they would be negligible as compared to the benefits from tankers.

Table 12-1-1 Prospected Revenue List

(Million L.E.)

Year	Dry Cargo	Oil		Total Revenue		Benefit	Remarks
		Ist Stage	Reopening	Ist Stage	Reopening		
1975	26.4		17.0		43.4		1. Revenue from dry cargo was assumed to increase at a yearly rate of 25% in and after 1986.
76	55.4		21.6		77.0		
77	58.3		15.2		73.5		
78	61.3		15.2		76.5		
79	64.5	58.5	15.1	123.0	79.6	43	2. Revenue from oil was assumed to remain on the same level from 1986 on.
80	68.0	64.5	17.8	132.5	85.8	47	
81	71.5	67.7	19.2	139.2	90.7	49	
82	75.4	70.2	20.6	145.6	96.0	50	3. Canal is assumed to be reopened in June 1975 so that only 50% of yearly revenue is listed for the first year.
83	79.5	73.9	32.3	153.4	111.8	52	
84	83.8	78.6	24.7	162.4	108.5	54	
85	88.4	82.0	26.4	170.4	114.8	56	
86	90.6			172.6	117.0		
87	92.9			174.9	119.3		
88	95.2			177.2	121.6		
89	97.6			179.6	124.0		
90	100.0			182.0	126.4		
91	102.5			184.5	128.9		
92	105.1			187.1	131.5		
93	107.7			189.7	134.1		
94	110.4			192.4	136.8		
95	113.2			195.2	139.6		
96	116.0			198.0	142.4		
97	118.9			200.9	145.3		
98	121.9			203.9	148.3		
99	124.9			206.9	151.3		
2,000	128.0			210.0	154.4		
01	131.2			213.2	157.6		
02	134.5			216.5	160.9		
03	137.9			219.9	164.3		
04	141.3			223.3	167.7		
05	144.9			226.9	171.3		
06	148.5			230.5	174.9		
07	152.2			234.2	178.6		
08	156.0			238.0	182.4		
Total						1,639	

1-3 Analysis

The Internal Rate of Return is estimated to be 11.5% from costs and benefits. Taking into consideration the fact that the interest on the yen loan from Japan is 2.0% and the official rate in Egypt is 5.0% (as of November, 1974), this project of which Internal Rate of Return is 11.5% may fairly be considered feasible from the national economic point of view.

Various assumptions have been adopted in the course of reaching the final economic evaluation. These assumptions have always been so arranged that the evaluation wonld be on the safer side. However, if the following changes in situation take place, or if a little more optimistic way of looking at things is adopted, a higher value of Internal Rate of Return will be given.

a. Oil demand was forecast in consideration of the recent policies in Europe and America to cut the energy consumption. But if it grows with the drop of oil price, the importation of oil will gain and so will the volume of oil that passes through the Suez Canal. This will lead to the increase of benefits.

b. The transit volume through the Suez Canal was assumed to remain on the same level after 1985. However, if we consider the future life of oil energy and the amount of oil production in Europe and America within their own territory, the volume of oil to flow from the Middle East to Europe and America may possibly increase to some extent even after 1985.

c. The team adopted the current toll system of the Canal to calculate the benefits, but when a new system is set up a sharp increase in the revenue can be expected. As a result of this, the benefits of expansion is anticipated to increase.

d. Costs were limited only to those related to the first phase project and none of those related to the reopening were included. However, the costs for the first-phase project include those for revetment removal, etc. which should essentially be covered by the second phase project.

Table 12-1-2 Table of Economic Analysis

(Million LE)

Year	Cost				Benefit	Discount Rate 11%		Discount Rate 12%	
	Construction	Maintenance Dredging	Administration	Total		C	B	C	B
1975	48	–	–	48	–	48	–	48	–
76	103	–	–	103	–	93	–	92	–
77	108	–	–	108	–	88	–	86	–
78	61	–	–	61	–	45	–	43	–
79		(0.7)	(4.9)	6	43	4	28	4	27
80		↑	(5.3)	6	47	4	28	3	27
81			(5.6)	6	49	3	26	3	25
82			(5.8)	7	50	3	25	3	23
83			(6.1)	7	52	3	23	3	21
84			(6.5)	7	54	3	21	3	19
85			(6.8)	8	56	3	20	3	18
86			(6.9)	8	↑	3	18	2	16
87			(7.0)	8		2	16	2	14
88			(7.1)	8		2	14	2	13
89			(7.2)	8		2	13	2	11
90			(7.3)	8		2	12	1	10
91			(7.4)	8		2	11	1	9
92			(7.5)	8		1	10	1	8
93			(7.6)	8		1	9	1	7
94			(7.8)	9		1	8	1	7
95			(7.9)	9		1	7	1	6
96			(8.0)	9		1	6	1	5
97			(8.1)	9		1	6	1	5
98			(8.2)	9		1	5	1	4
99			(8.3)	9		1	5	1	4
2000			(8.4)	9		1	4	1	3
01			(8.6)	9		1	4	1	3
02			(8.8)	10		1	3	0	3
03			(8.9)	10		1	3	0	2
04			(9.0)	10		0	3	0	2
05			(9.1)	10		0	2	0	2
06			(9.2)	10		0	2	0	2
07			(9.4)	10		0	2	0	1
08		↓	(9.5)	10	↓	0	2	0	1
Total				573	1,639	322	336	310	298
						14		12	

Notes: $IRR = 11 + \frac{14}{14 + 12} = 11.5\%$

2. Financial Analysis

2-1 Preconditions

Due to the reasons itemized below it is extremely difficult to forecast the financial situation of S.C.A. after the first-phase project. Therefore, the financial forecast includes portions based on considerably bold assumptions or preconditions.

1) Reopening plan and extension project include unknown factors . . . especially the amount of loan to be procured, its terms and conditions, and the method of securing local currency fund, etc. are not known.

2) Loss of data owing to the evacuation of the S.C.A. Headquarters or war damages made it impossible to give substance to some of the past data.

3) The newest data available for estimating the expenses incidental to the Canal operation are those of seven years and a half ago, and are accordingly low in reliability as the base for forecast.

4) The fixed assets shown in the existing financial statements seem to be considerably far from actuality owing to the evacuation or war damages. The fixed assets shonld therefore be revaluated at an earliest date.

5) A new toll system to be applied after the reopening of the Canal has not been established yet. S.C.A. entrusted three consulting firms from Japan, Norway and England to study the new system applicable at the time of reopening. It is expected that S.C.A. will finalize it taking carefully into account the results of the study and the trend of world's shipping industry.

The following are the principal assumptions adopted for the financial forecast.

1) Revenue from transit tolls

This revenue was estimated by multiplying the transit tolls in 1967 (before the closure of the Canal) by the expected net tonnage (SCNRT) of passing vessels which was given through the economic analysis. Other small charges like berthing dues were disregarded.

2) Revenue from related business

An increase through the expansion of business scale was taken into account in addition to L.E. 3 million of yearly mean revenue.

3) Maintenance dredging cost

As this cost was estimated at L.E. 1.4 million per year (in 1974 price), an annual increase of 3% was considered.

4) Other maintenance & management cost

Assuming that this cost will grow in proportion to the increase in revenue from transit tolls after 1979 (after completion of the first-phase project), an annual increase of 3% was considered.

5) As for the assets to be acquired after the reopening, the mean depreciation period and rate were assumed, and estimated depreciation expense for the existing facilities was added. On the other hand, the fixed rate system was applied to the depreciation in accordance with the explanation of the S.C.A.

6) Royalty

5% of the total revenue was assumed to be paid every year to the government, as was the case in the past.

7) Interest payable

a) Interest on loans already introduced

The loan from the Central Bank from 1967 to 1973 (amounting to L.E. 18 million) was assumed to be repayed within 10 years (inclusive of a grace period of 4 years) starting from 1975 at an interest rate of 4.5%, while the principal and interest of the government loan extended so far were assumed to be shelved up.

b) Fund for reopening

Necessary funds for the reopening were assumed to be raised by the following method.

Table 12-2-1 Method of Raising Funds (Reopening)

(Unit: Million L. E.)

Cost		Funds		Conditions
Local currency requirements	44.5	Loan from IBRD	20.8	8%, 20 years (inclusive of 4 year grace period)
Foreign currency requirements	75.5	Other foreign loans	54.7	4.5%, 20 years (-do-)
		Debt in local currency	24.5	4.5%, 20 years (-do-)
		Owned capital	20	
Total	120		120	

c) Fund for the first-phase project

The following method was applied to the first-phase project.

Table 12-2-2 Method of Raising Funds (First Phase Project)

(Unit: Million L. E.)

Cost		Funds		Conditions
Local currency requirements	119.8	Yen loan	49.5	2%, 25 years (inclusive of 7-year grace period)
Foreign currency requirements	200.2	Other foreign loans	150.7	4.5%, 20 years (inclusive of 4-year grace period)
		Debt in local currency	79.8	5.4%, 20 years (-do-)
		Owned capital	40	
Total	320		320	

8) Income tax

The current tax rate of 39.7% was applied to the profit after interest. The breakdown of the current tax rate is as follows according to S.C.A.

Commercial & Industrial Market Tax	17.0%
Municipal Tax (10% of the above)	1.7%
Defense Tax	10.5%
National Security Tax	8.0%
Djihad Duty	2.5%
Total	39.7%

It is to be added that the income tax before 1975 was disregarded due to the loss in the last three years.

9) Amount to be paid to the National Treasury

The government share that used to be paid to the National Treasury from the net profit was not considered.

2-2 Forecast of Profit and Loss

The results of a trial calculation of profit and loss for the period of 1974 to 2000 on the basis of above assumptions are shown in Table 12-2-3.

According to the said table, the net loss in 1974 after paying the royalty, income tax and interests is found to be L.E. 7.9 million, but S.C.A. will register black figures

after the reopening of the Canal (expected to be in the middle of 1975). During the first phase project after the reopening, however, there will be an increase in the interest on loans and depreciation expense, and the revenue from transit tolls will remain on the approximately L.E. 70 million level so that the level of profit will be by far behind that recorded in the past Canal operating period (L.E. 50.5 million in 1965, L.E. 54.3 million in 1966 and L.E. 57.7 million in 1967; revenues from transit tolls in these years stood at L.E. 83.1 million L.E. 91.3 million and L.E. 94.5 million respectively).
It is only in and after 1980, when the revenue from transit tolls increases to a great extent after the completion of the first-phase project and at the same time the interest and depriciation expense pass their peak, that the profit begins to show a constant upward tendency.

2-3 Forecast of Cash Flow Statement

The forecast of Cash Flow Statement for the period of 1974 to 2000 basing upon the assumptions given in 2-1 above is shown in Table 12-2-4.

Judging from the said table, a substantial part of the funds for the first phase project (1975-1978) must be financed by loans. However, there is no need of apprehension about the balance of capital in and after 1977 when the payment of interest on the loans raised for the first phase project is supposed to start on a full scale, and especially in and after 1980 when the repayment of the principal of those loans is designed to start.

2-4 Conclusions and Problems

The procurement of most of the funds required for the Canal Reopening Scheme being carried out at present by the government and S.C.A. can be considered to have already acquired a definite outlook.

The S.C.A.'s plan for raising funds is shown in Table 12-2-5.

Table 12-2-3 Forecast Statement of Profit and Loss of S.C.A. (1974 ~ 2000)

(Million L.E.)

	Income					Expenses									Other Expenses		
	Transit Tolls			Income from Rlated Business	Grand Total	Operation Cost			Depreciation	Grand Total	Operational Profit or Loss	Royalty	Profit or Loss Before Tax and Interest			Net Profit or Loss
	Cargo	Oil	Total			Maintenance Dredging	Other Maintenance & Management	Total						Interest Payable	Income Tax	
1974	–	–	–	3	3	–	8	8	1.9	9.9	6.9	0	△6.9	1	–	△7.9
75	26.4	17.0	43.4	3	46.4	0.7	9	9.7	3.1	12.8	33.6	2.3	31.3	4.7	–	26.6
76	55.4	21.6	77	3	80	1.5	10	11.5	6.6	18.1	61.9	4	57.9	7.1	20.2	30.6
77	58.3	15.2	73.5	3	76.5	1.5	10.5	12	11.5	23.5	53	3.8	49.2	12.9	14.4	21.9
78	61.3	15.2	76.5	3	79.5	1.5	11	12.6	15.3	27.9	51.6	4	47.6	16	125	19.1
79	64.5	73.6	138.1	3	141.1	1.5	11.6	13.2	16.6	29.8	111.3	7.1	104.2	16.3	34.9	53
1980	68.0	82.3	150.3	3.5	153.8	1.7	13.0	14.7	15.3	30	123.8	7.7	116.1	15.2	40.1	60.8
81	71.5	86.9	158.4	3.5	161.9	1.7	13.8	15.5	14	29.5	132.4	8.1	124.3	14.2	43.7	66.4
82	75.4	90.8	166.2	3.5	161.7	1.8	14.8	16.6	13.1	29.7	140	8.5	131.5	12.9	47.1	71.5
83	79.5	106.2	185.7	3.5	189.2	1.8	16	17.8	12	29.8	159.4	9.5	149.9	11.9	54.8	83.2
84	83.8	103.3	187.1	3.5	190.6	1.9	17.5	19.4	11	30.4	160.2	9.5	150.7	10.7	55.6	84.4
1985	88.4	108.4	196.8	4	200.8	1.9	18.8	20.7	10.2	30.9	169.9	10	159.9	9.7	59.6	90.6
86	90.6	108.4	199	4	203	2	19.7	21.7	9.4	31.1	171.9	10.2	161.7	8.6	60.8	92.3
87	92.9	108.4	201.3	4	205.3	2.1	20.6	22.7	8.6	31.3	174	10.3	163.7	7.7	61.9	94.1
88	95.2	108.4	203.6	4	207.6	2.1	21.5	23.6	8	31.6	176	10.4	165.6	6.6	63.1	95.9
89	97.6	108.4	206	4	210	2.2	22.4	24.6	7.4	32	178	10.5	167.5	5.7	64.2	97.6
1990	100.0	108.4	208.4	4.5	212.9	2.2	23.4	25.6	6.8	32.4	180.5	10.6	169.9	4.6	65.6	99.7
91	102.5	108.4	210.9	4.5	215.4	2.3	24.5	26.8	6.2	33	182.4	10.8	171.6	3.7	66.7	101.2
92	105.1	108.4	213.5	4.5	218	2.4	25.5	27.9	5.7	33.6	184.4	10.9	173.5	2.6	67.8	103.1
93	107.7	108.4	216.1	4.5	220.6	2.5	26.8	29.3	5.3	34.6	186	11	175	1.7	68.8	104.5
94	110.4	108.4	218.8	4.5	223.3	2.5	28	30.5	5	35.5	187.8	11.2	176.6	0.9	69.8	105.9
1995	113.2	108.4	221.6	5	226.6	2.6	29.2	31.8	4.5	36.3	190.3	11.3	179	0.5	70.9	107.6
96	116.0	108.4	224.4	5	229.4	2.7	30.7	33.4	4.2	37.6	191.8	11.5	180.3	0.2	71.5	108.6
97	118.9	108.4	227.3	5	232.3	2.8	32	34.8	3.8	38.6	193.7	11.6	182.1	0.1	72.3	109.7
98	121.9	108.4	230.3	5	235.3	2.8	33.5	36.3	3.6	39.9	195.4	11.8	183.6	0.1	72.8	110.7
99	124.9	108.4	233.3	5	238.3	2.9	35	37.9	3.3	41.2	197.1	11.9	185.2		73.5	111.7
2000	128.0	108.4	236.4	5.5	241.9	3	36.7	39.7	3	42.7	199.2	11.1	187.1		74.3	112.8

Table 12-2-4 Forecast Cash Flow Statement of S.C.A. (1974 ~ 2000)

(Unit: Million L.E.)

	Required Funds								Raising of Funds									Difference Between Incomes and Outgoings
	Construction Cost			Debt/Service			Income Tax	Grand Total	Owned Capital			Loan					Grand Total	
	Reopening	1st-phase Project	Total	Payment of Interest	Repayment	Total			Profit or Loss Before Tax & Interest	Depreciation	Total	Reopening	1st-phase Project: Yen Loan	1st-phase Project: Others	1st-phase Project: Total	Total		
1974	32.5		32.5	1	–	1	–	33.5	△6.9	1.9	△5	40	–	–	–	40	35	1.5
75	45.8	48	103.8	4.1	–	4.1	–	107.9	31.3	3.1	34.4	40	15.8	22.2	38	78	112.4	4.5
76	29.2	103	132.2	7.1	–	7.1	17.2	156.5	57.9	6.6	64.5	15	13.5	79.5	93	108	172.5	16
77	12.5	108	120.5	12.9	–	12.9	10.4	143.8	49.2	11.5	60.7	5	13.5	94.5	108	113	173.7	29.9
78		61	61	16	7	23	6.1	90.1	47.6	15.3	62.9		6.7	34.3	41	41	103.9	13.8
79	(120)	(320)	(440)	16.3	9.2	25.5	27.8	53.3	104.2	16.6	120.8	(100)			(280)	(380)	120.8	67.5
1980				15.2	23.7	38.9	33.8	72.7	116.1	15.3	131.4						131.4	58.7
81				14.2	23.6	37.8	38.2	76	124.3	14	138.3						138.3	62.3
82				12.9	26.3	39.2	42.2	81.4	131.5	13.1	144.6						144.6	63.2
83				11.9	26.3	38.2	50.5	88.7	149.9	12	161.9						161.9	73.2
84				10.7	26.3	37	51.8	88.8	150.7	11	161.7						161.7	72.9
1985				9.7	23.3	33	56.3	89.3	159.9	10.2	170.1						170.1	80.8
86				8.6	23.3	31.9	57.8	89.7	161.7	9.4	171.1						171.1	81.4
87				7.7	23.3	31	59.4	90.4	163.7	8.6	172.3						172.3	81.9
88				6.6	23.3	29.9	60.9	90.8	165.6	8	173.6						173.6	82.8
89				5.7	23.3	29	62.3	91.3	167.5	7.4	174.9						174.9	83.6
1990				4.6	23.3	27.9	63.9	91.8	169.9	6.8	176.7						176.7	84.9
91				3.7	23.3	27	65.2	92.2	171.6	6.2	177.8						177.8	85.6
92				2.6	23.3	25.9	66.5	92.4	173.5	5.7	179.2						179.2	86.8
93				1.7	23.3	25	67.7	92.7	175	5.3	180.3						180.3	87.6
94				0.9	17.1	18	68.8	86.8	176.6	5	181.6						181.6	94.8
1995				0.5	17.1	17.6	70	87.6	179	4.5	183.5						183.5	95.9
96				0.2	27	2.9	70.8	73.7	180.3	4.2	184.5						184.5	110.8
97				0.1	27	2.8	71.6	74.4	182.1	3.8	185.9						185.9	111.5
98				0.1	27	2.8	72.3	75.1	183.6	3.6	187.2						187.2	112.1
99				0	27	2.7	73.1	75.8	185.2	3.3	188.5						188.5	112.7
2000				0	0.9	0.9	73.9	74.8	187.1	3	190.1						190.1	115.3

Table 12-2-5 Plan for Raising Funds for the Canal Reopening Scheme

(Unit: Million US$)

		Local currency	Foreign currency	Total			Local currency	Foreign currency	Total
Item	Fairway improvement	32.10	110.45	142.55	Source	Kuwait fund		33	
	Rehabilitation of machine shops	2.90	10.25	13.15		U. S. A.		7	
	Buildings and roads	20.20	7.44	27.64		Saudi Arabia		50	
	Others	30.05	28.21	58.26		Abu Dhabi		33	
	Consulting services	0.30	0.96	1.26		Qater		10	
	Sub-total	85.55	157.31	242.86		I B R D		50	
	Contingency	21.45	23.69	45.14		Government, S.C.A.	110	–	
	Total	107.00	181.00	288.00		Total	110	183	293

Source: Items from "The IBRD Appraisal Report (74/11)", Sources from interview with S.C.A.

Note: Discordance between the right and left sides is mostly due to the difference in exchange rate.

As for the first phase project, no loan was pledged except the Japanese yen loan during the team's stay in Egypt. The Egyptian government, however, is now sounding Iran, Saudi Arabia and other oil-producing countries as well as the countries in Europe and North America for financial aid, and and it seems that the decision will soon be made coupled with the materialization of an international tender for the first phase project.

Nevertheless, loans for construction of the first phase project including the cost of the Canal reopening are, as mentioned above, repayable from the transit tolls after the Canal is reopened and the first phase project completed, and there is no problem in the capital balance. (The revenue from transit dues was estimated on the basis of 1967 toll rates and when this is raised in future, the balance will naturally improve.)

Accordingly, the following will be pointed out as matters of consideration when raising funds for the first phase project.

a) To expedite the reopening of the Canal so as to earn the revenue from transit dues;

b) To secure urgently the resources of foreign currency loans; and

c) To assure that the government will take adequate budgetary measures to secure local currency funds so as not to cause any hindrance to the progress of works to be undertaken directly by S.C.A. or by local contractors and to the payment in local currency for the works to be covered Japanese yen loan.

3. Evaluation from Social Point of View

3-1 Effects on Egyptian Society

The following are conceivable as the effects of the project on the Egyptian economy.

a) The revenue earned by the Canal operation is colossal, and the foreign currency thus acquired will increase the influence of Egypt over the international community and also will contribute greatly to the promotion of trade.

b) A part of the Canal revenue will be paid directly to the government as royalty or tax and will serve to strengthen the Egyptian national finance. And indirectly it will serve for the betterment of welfare of the Egyptian people.

c) Control of the Canal which is of great importance to not only Europe and America but also all other countries of the world gives unnegligible backing for increasing Egyptian influence over the international political community.

d) Those vessels that pass through the Canal may not, in most cases, bring any other benefit to Egypt than the payment of transit tolls. Vessels of this kind should by no means destroy the living environments of the people in local communities along the Canal, nor should they be allowed to cause any accident or let oil flow out inside the Canal. In this regard, the establishment of safety measures that may meet the requirements more than enough is desirable.

e) Total construction cost for the first phase project alone amounts to L.E. 3.2 thousand million while the portion in local currency stands at L.E. 1.2 thousand million. An increase in employment of manpower and influences over the Egyptian industries to come out of this huge capital input are immense. Also the civil engineering techniques to be fostered and accumulated through the earthwork and revetment works may greatly contribute to other development projects to follow.

f) It is expected that economic activities in and around the Canal may also prosper when the Canal is reopened and its cross section is expanded and the volume of passage increases. Approximately one million people are said to have settled down in this vicinity prior to the Middle East War, and 800,000 to 90,000 of them have returned to their homes so far. When Lesseps first commenced the construction of the Canal, this place was a desert only inhabited by 3,500 people or less. Since then, the Suez Maritime Canal Company had undertaken various works all by itself to make a sweet-water canal from the Nile for the excavation of the Canal, to install water supply and drainage facilities and to secure electricity, etc. Thus, cities, forests and hilly areas were formed in the vicinity. S.C.A. is still managing those principal public facilities in the towns of Port Said, Port Fouad and Ismailia, etc., and the enrichment of its finances is considered to have considerable influence on the development and progress of places along the Canal. Deserts are easily convertible into fertile plains with the construction of artificial water channels. Mr. Osman, Minister of Construction, announced a large-scale improvement plan. In the present situation, no financial backing is available for such a plan, but as the revenue from the Canal comes to show its size in future, plans for developing industrial areas, harbors and resort areas around the Canal will be worked out one after another. The completion of the first phase project seems to accelerate such movement further.

3-2 Effects on International Economic Community

Judging from the internationalism involved in the Suez Canal, effects of this project over the international society, especially the shipping circles, are enormous. The following will be pointed out in connection with the Canal expansion.

a. A part of the merit of expansion is to be enjoyed by tanker-owners and accordingly is expected to be returned indirectly to the international society in the shape of cutdown of oil transportation cost. Particularly, effects on the economy of Southern Europe will be very big.

b. In the short term, however, since the Canal will offer a short-cut, the turnover rate of tankers will improve and surplus of tonnage will occur. Therefore, it will become necessary to have another look at the tanker construction program while judging the supply-demand of oil. In that case, the type of tankers will be possibly divided into two, one is Suez Max and the other is ULCC, after looking far ahead into the second phase project.

ACKNOWLEDGEMENTS

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The team gratefully notes the whole-hearted cooperation of the SCA staff that made the survey more fruitful than expected despite of its limited stay in Cairo, and wishes to express its heartfelt gratitude.

The team does not stint its praise for the enthusiasm and efforts of the SCA staff that were shown by way of providing all the necessary data from respective departments in spite of the fact that their days had been busy preparing for the Canal reopening and besides they had just moved into the new office building with many of the data scattered and lost because of war damages.

The team, at the same time, was quite encouraged at the eagerness and willingness of those officers in the field engaging in the rehabilitation of such facilities as regional offices, workshops and dredgers, as well as in sweeping of the Canal, digging-up of bollards and reconstruction of navigation aids, all for the sake of reopening the Canal. Acknowledgements are heartily extended to those staffs who accompanied the team all the way for the proper guidance of its field observation, taking much of precious time off their busy work.

It is to be added that all the team members are earnestly hoping for the earliest possible reopening of the Canal.

Further, the team sincerly expects that Egypt and Japan may have more opportunities in the future to cooperate in many ways regarding the expansion or operation of the Canal, and hopes such cooperation will serve for the furtherance of the friendship and prosperity of both countries.

It will be worth trying to find as many chances as possible to realize such wishes. For example, the rivival of exchange of engineers and of stationing of harbor engineers at the Embassy of Japan in Egypt that were suspended due to war, and the training in Japan of pilots or tug-masters in maneunering super-sized vessels in order to secure greater safety for the passage of the Canal.

As a token of respect for those who, despite the claims of busy days, had willingly extended the utmost cooperation during the team's stay in Egypt, the team has the honor to list hereunder their names, though not all of them.

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