CHAPTER 3 STANDARD DESIGN OF STRUCTURES

3-1 Types of Structures

The port facilities which are urgently required and have to be constructed or improved by 1983 as part of the development project of the Port of Colombo are given below.

① Crane Foundation of the Queen Elizabeth Quay No. 5
The possiblity of installing a container crane on the existing quaywall and thus transform the wharf into a container berth shall be examined. If it is impossible to install a container crane on the quaywall under present conditions, the necessary design modifications for the wharf will be made.

② Queen Elizabeth Quay No. 4
With the containerization of the total length of 300 m of the Queen Elizabety Quay, part of the container crane rails, about 100 m of the total length of 300 m, will be installed on the Queen Elizabeth Quay No. 4 according to the containerization plan. The quaywall of the Queen Elizabeth Quay No. 4 is a concrete block-type, which is a different structual form from that of the Queen Elizabeth Quay No. 5. Engineering examination will be made to determine if it is possible to install a container crane on such a concrete block-type quaywall.

③ New Container Wharf
The standard design of the quaywall (design water depth −12 m), the bulkheads (design water depth −10 m and −7.5m), the container crane foundation, and the pavement of the marshalling yard are to be prepared for the new container wharf in the water area in front of the Coaling Jetties.

3-2 Crane Foundation of the Queen Elizabeth Quay No. 5

3-2-1 The Existing Queen Elizabeth Quay No. 5

This quay was constructed as an extension of the Queen Elizabeth Quay No. 4 by reclaming a length of 200 m and a width of 100 m on the port side of the South-West Breakwater. The construction work was started in 1971 and was almost completed of the end of 1979. The Queen Elizabeth Quay No. 5 refers in this chapter to the newly extended quay having a new quaywall structure. As originally designed and constructed, this structure probably has inadequate bearing capacity for a container crane, the design must be modified if it is to be safely used.

The quaywall's structural form is a type of cylindrical gravity-type caisson quaywall (which will be called "cylinder") as illustrated in Fig.-V.3.1. The cylinder is composed of 18 concrete cylindrical blocks (refered to as a "segment"), each of an outer diameter of 8.1 m, inner diameter of 6.9 m, height of 0.9 m, and weight of 24 tons, as shown in Fig.-V.3.2.

In executing the cylinder work, the segments were stacked over the previously leveled seabed, to form a unitary cylinder. When the elevation of the cylinders protruded from the sea surface, the inside of the cylinder was dredged with a grab, and the cylinder was settled to the bearing layer by its own weight. 40 vertical holes were fabricated within the wall of the cylinders; 20 holes were filled with underwater concrete to unite each segment, and the remaining 20 holes were filled with sand. The inside space of the cylinder is also filled with dredged sand. The design depth of the cylinder bottom is −15.6 m.

The central axis of the crane beam, which is constructed over the cylinder for the quay legs of the container crane, is located in a position 4.2 m away from the berthing plane, and this position is 0.45 m seaward of the central axis of the cylinder. Transfer beams for conveying the load of the container crane to the cylinders are constructed at an interval of 4.35 m, two on each cylinder. Design of the beam is made tentatively for the container crane specified in Table-V.3.1. But, the foundation work for the shore legs of the container crane is not yet carried out. It will be executed after the specifications fo the container crane are determined. Fig.-V.3.3 shows a design drawing of the beam prepared by the Sri Lanka Ports Authority.

In the Queen Elizabeth Quay No. 5, a total of 28 cylinders are used; every two cylinders are connected by a post-tensioned concrete tie beam to a third anchor cylinder, as shown in Fig.-V.3.4 and Fig.-V.3.5.

3-2-2 Stability Analysis of Cylinder for the Container Crane

In order to examine the bearing capacity and the stability against sliding and turn-over of the cylinder when it supports the quay leg of the container crane, calculations was made under the following conditions:

(1) Conditions Used in Calculation

a) Load
Container crane: Tables-V.3.1 and V.3.2
Surcharge: $3.0t/m^2$

b) Vertical force from the container crane
Wheel load during operation: 10% increase of the crane maximum wheel pressure

c) Horizontal force from the container crane
During operation: 10% of the maximum crane wheel pressure is applied to the cranebeam at a right angle to the direction of movement of the crane.

d) Tidal levels: +0.72m HWOST
±0.00m LWOST

e) Residual water level: +0.24m

f) Soil conditions
Back fill material:
Sand fill; +2.7m ~ +0.24m, $\phi=30^\circ$, $\gamma=1.8t/m^3$
Sand fill; +0.24m ~ −15.6m, $\phi=30^\circ$, $\gamma=1.0t/m^3$
Existing seabed in front of the cylinder
Sand; −12.6m ~ −15.6m, $\phi=30^\circ$, $\gamma=1.0t/m^3$

g) Water depth in front of the cylinder: −12.6m

h) Bulk density of concrete cylinder: $2.30t/m^3$

i) Bulk density of concrete beam and coping: $2.45t/m^3$

j) Safety factor of the anchor: 2.5

k) Design seismic coefficient: 0

l) Coefficient of friction at the cylinder bottom: μ=0.58

m) Angle of friction at the cylinder wall: δ=15°

n) Critical wind velocity for operation of the container crane: 16m/sec

o) Wind velocity during storm: 50m/sec

(2) Assumptions Used in Calculation

① Sand fill in the cylinders behaves in one unit, and the cylinder is regarded as a rigid wall as a whole.

② Earth pressure acting on the cylinder is directed toward the central axis of the cylinder.

③ Any change of the buoyancy and the cylinder weight due to tilting of the cylinder is disregarded.

④ Any decrease of the area in the bottom due to tilting of the cylinder is disregarded.

⑤ Stability analysis on a single cylinder is made independently of continuous quaywall.

(3) Results of Calculation

The analysis of the bearing capacity of the cylinders shows that this design is inadequate as constructed, and will probably fail under load. Calculation confirmed that with the container crane placed over the cylinder, the safety factors of the cylinder against sliding, turn-over and bulging of the embedment of the cylinder would be more than 1.2, 1.2 and 1.5 respectively. However, with respect to the bearing capacity of the cylinder, it was found doubtful whether a base layer could sufficiently bear and safely support the load of the container crane.

Fig.-V.3.6 shows the N-value by standard penetration test on/around the Queen Elizabeth Quay No. 5 and the design cross-section of the cylinder. According to the drawing, the possibility of the cylinder bottom being located in a layer with N-value of 9 to 10 is very high, and it seems likely that the cylinder loaded with the container crane will cause a soil failure in this layer. The analysis on the bearing capacity of the cylinder will be discussed in detail below.

1) External Force due to a Container Crane

a) During Operation

Table-V.3.1 shows the specification of the container crane which the Sri Lanka Ports Authority used in the design of the beams. Table-V.3.2 shows the specifications of the typical container cranes used at the container terminals in Japan. From these tables, the relationships between the gross weight of the container crane and the maximum wheel load is given as shown in Fig.-V3.7. The maximum wheel load of the quay leg at 38.2t/wheel and that of the shore leg at 32.45/wheel are obtained. It is, of course, obvious that the maximum wheel load of the quay leg and shore leg differ by the type of container crane, but so long as the foregoing values are employed, they are compatible with those for container cranes generally used.

b) During Storm

Fig.-V.3.8 is a diagrammatic representation of Table-V.3.2 of the maximum wheel load during storm. A maximum wind velocity of 50m/sec is assumed in Fig.-V.3.8. The maximum wind velocity in the Port of Colombo is 38m/sec (50-year wind) as described in I-2 Natural Conditions, and the maximum wheel load of the quay leg of the crane during storm is less by 2.3t/wheel than that during operation, as shown in Fig.-V.3.8. Thus, it is sufficient to analize the stability of the cylinder during operation, and assume that this stability also applies to storm conditions.

2) Toe Pressure at Cylinder Forefoot

a) During operation

The toe pressure at the forefoot of the cylinder bottom obtained under the conditions stated in V-3-2-2 (1) is shown in Fig.-V3.9. In the drawing, a container crane with an 8 wheel/leg has greater toe pressure than that with a 6 wheel/leg due to the influence value of the vertical load conveyed to the cylinder through the transfer beams A and B. This was obtained by taking the crane beam as an infinite span, thus the valve is greater for an 8 wheel/leg than a 6 wheel/leg crane as shown in Fig.-V.3.10. When a generally used container crane is installed on the cylinder, a toe pressure of $39.3t/m^2$ to $41.6t/m^2$ is generated.

3) Examination of the Bearing Capacity

Figs. -V.3.11(a) and V.3.11(b) show the allowable bearing capacity in the cases of the cylinder being based on a clay and a sand layer. The allowable bearing capacities q_a are calculated by the following formulas:

$$q_a = N_c \frac{c}{F_s} + \gamma_2 D_f \qquad (t/m^2) \qquad \text{(Clay)}$$

$$q_a = \frac{1}{F_s} (\beta \gamma_1 B N_\gamma + \gamma_2 D_f N_q) + \gamma_2 D_f \quad (t/m^2) \qquad \text{(Sand)}$$

where:

N_c, N_q and N_γ : Coefficients of bearing capacity

F_s : Safety factor, 3

γ_1 and γ_2 : Bulk density $1.0t/m^3$

c : Cohesion (in t/m^2), assumed to be constant in the foundation subgrade

ϕ : Internal friction angle (in degree), assumed to be constant in the foundation subgrade

β : Shape factor of the foundation, circular, 0.3

Figs.-V.3.11 (a) and V.3.11 (b) show the relationships between c , ϕ and the N-value obtained through the following fomulas:

Clay:

$$q_u = 2c \fallingdotseq \frac{N}{8}$$

Sand:

$\phi = \sqrt{12N} + 15,$ Poor grading and round particle

$\phi = \sqrt{12N} + 25,$ Well grading and angular particle

$\phi = \sqrt{12N} + 20,$ Well grading and round particle
Poor grading and angular particle

Figs.-V.3.11(a) and V.3.11(b) indicate the N-values of the layer to be required to resist the toe pressure at the bottom of the cylinder. The N-values required for installation of the container crane on the cylinder are:

For clay layer;	N-value	21-22
For sand layer;	N-value	15-16 (poor grading and angular particles, or well grading and round particles)
	N-value	28-29 (Poor grading and round particles)

On the other hand, the soil survey gave N-value of 9 to 10 for the clayey sand layer at/around the cylinder bottom, as shown in Fig.-V.3.6. According to the record of the actual cylinder work, the number of segments used for the respective cylinders is 18, except the cylinder No. 9, which tilted during the construction work. Between the respective segments, a rope is placed as a seal material to prevent flow-out of the sand fill so that the depth of the bottom from the crown of each cylinder is 18.75m at best with such seal taken into account. The depth of the clayey sand layer of the N-value of 9 to 10 from the crown goes down to a maximum of 20.60m, thus, the cylinder bottom is resting in a layer of weak clayey sand, about 1.85m shallower than the required depth. In order to install a container crane on the Queen Elizabeth Quay No. 5, improvement work will be required.

3-2-3 Improvement Work of the Queen Elizabeth Quay No.5

For reinforcement or improvement of the Queen Elizabeth Quay No.5, the following two methods may be considered:

① Construction of pile foundations for the support of the crane load

② Improvement of the subsoil below the cylinder bottom to support the crane load.

Upon comparison of these methods with each other, method ① was found to be better because the effect is reliable, the work period is shorter and construction work is easy.

Figs.-V.3.12(a) and V.3.12(b) show the quaywall of the Queen Elizabeth Quay No.5 after improvement. The straight piles driven into the cylinder connected to the batter piles on the shore side by means of wire ties having the characteristics shown in Table-V.3.3, since horizontal resistance of the piles are not sufficient. The safety factor of the wire ties have a value of 5 or more for the tensile load. For the other design conditions, the same conditions in V-3-2-2 (1) are used.

With respect to whether the rail span of the container crane should be 16m or 24m, the conclusion that shorter span would be preferable in that the wire ties were used for the improvement works. Thus, rail span of 16m is employed.

3-3 Crane Foundation of the Queen Elizabeth Quay No. 4

3-3-1 The Existing Queen Elizabeth Quay No. 4

Fig.-V.3.13 shows a typical cross-section of the quaywall (called "block work" below) of the Queen Elizabeth Quay No. 4. The block work is a concrete block-type gravity quaywall, with a bottom depth of 11.4m, which is shallower than the cylinder bottom depth at −15.6m of the Queen Elizabeth Quay No. 5. A rubble base with a minimum thickness of 1.2m is provided beneath the bottom of the block work. When the crane rails are extended from the Queen Elizabeth Quay No. 5, the rail for the quay leg of the crane is located on the shore side 0.75m away from the central axis of the block work.

3-3-2 Stability Analysis of the Block Work for a Container Crane

Under conditions similar to those described in V-3-2-2 (1), the toe pressures were calculated at the bottom of the block work and that of the rubble base. The results are shown in Fig.-V.3.14. The toe pressure decreases with increasing maximum wheel loading because the line of force of the container crane is located toward the shore side from the central axis of the block work, and the degree of eccentricity of the total load at the bottom of the block work is reduced.

Figs.-V.3.15(a) and V.3-15(b) show the curves of allowable bearing capacity q_a versus cohesion c or internal friction angle ϕ versus N-value, obtained for the block work shown in Fig.-V.3.13. From Figs.-V.3.15(a) and V.3.15(b), the N-values allowing installation of the container crane on the block work are:

For clay layer;	N-value	32-33
For sand layer;	N-value	18-19 (Poor grading and angular particles, or well grading and round particles)
	N-value	33-34 (Poor grading and round particles)

3-3-3 Feasibility of the Queen Elizabeth Quay No. 4 for a Container Quay

The soil survey at/around the Queen Elizabeth Quay No. 4 found that the clayey sand layer with N-value of 14 was present at a depth of −15.50m to −16.60m, so that it is impossible to place a container crane on the block work under present conditions. If a 300m container berth is desired, improvements must be made for about 100m of the block work. However, as shown in Fig.-V.3.13, the block work is a structure of concrete blocks so that the improvement work is more difficult compared to that of the cylinder of Queen Elizabeth Quay No. 5. Further, though there may be disadvantages in operation of a 200m berth length, reduced from 300m, a 200m long berth is sufficient for container handling. Thus, it was decided that no container crane would be placed on the block work of the Queen Elizabeth Quay No. 4.

3-4 New Container Wharf

The standard designs of structures on the new container wharf are for a caisson-type quaywall (design depth −12m) bulkheads (design depth −10m and −7.5m), container crane foundation, and pavement of the container yard. The gravity-type quaywall is a better structure for the Urgent Plan, as described in V-4-2, so that this type of quaywalls is used.

(1) Caisson-Type Quaywall (design depth: −12m)

Figs.-V.3.16(a) and V.3.16(b) show a cross-section of the quaywall of the new container wharf and a plane view of the quaywall. The conditions used in design are as follows:

a) Design water depth: −12m LWOST
b) Tidal levels: HWOST +0.72m
   LWOST ±0.00m
c) Work datum level: ±0 LWOST
d) Crown height: +2.7m LWOST
e) Design loads:
   Uniform load, 3.0t/m^2 (Stack of 3 containers)
   Container crane load, 38.2 t/wheel for quay leg

   Provided that the vertical wheel load during operation is a 10% increase in the maximum crane wheel load, and the horizontal load during operation is a 10% of the crane maximum wheel load in a right angle direction to the crane traveling direction.

f) Critical wind velocity during operation: 16m/sec
g) Wind velocity during storm: 50m/sec
h) Residual water level: +0.24m LWOST
i) Soil conditions: Rock below −15m LWOST
j) Specific gravity of reinforced concrete: 2.45 t/m^3
k) Coefficient of friction: 0.6
l) Safety factor:
   Siding 1.2
   Turn-over 1.2
   Bearing capacity against eccentric load 1.5

m) Allowable toe pressure: 50 t/m²

n) Design seismic coefficient: 0

(2) Bulkhead (design water depth: – 10m)

A typical cross-sectional view of the bulkhead at the Korteboam Quay and a plane view of the caisson are shown in Figs.-V.3.17(a) and V.3.17(b). Design conditions are as follows:

a) Design water depth: –10m LWOST

b) Crane load: Not applied on this bulkhead

c) Soil condition: Rock below –13m LWOST

and other design conditions are the same with those in V-3-2-4 (1).

(3) Bulkhead (design water depth –7.5m)

In Figs.-V.3.18(a) and V.3.18(b) are shown a typical cross-sectional view of the bulkhead and a plane view of the caisson. The design conditions are the same with those in V-3-2-4(2), except the design water depth of –7.5m.

(4) Container Crane Foundation during Storm

For the foundation supporting the quay leg of the container crane, it is not required to construct a particular structure, as stated in V-3-2-2. For the foundation on the shore leg of the container crane, the pile foundation used on the land side shall be a batter pile driven at an angle of 15° as shown in Fig.-V.3.16(b). According to the maximum wind velocity 38 m/sec (50-year wind) in the Port of Colombo, the wind load shall be calculated after determination of the crane specification, and the detail design of the foundation conforming to such wind load shall be made.

(5) Pavement of the Container Yard

Pavement of the container yard shall be of heavy pavement of asphalt concrete over the whole surface of the yard. In design of the pavement, the wheel load should be determined upon estimation of the passing traffic in the container yard. But, as there are many factors that are not determinable at present, such as types of the container ships calling, time schedule, kinds and quantities of the cargoes, ratio of stacking, and method of operation by the users of the container yard, the design shall be made with a design wheel load of 13t, similar to the asphalt concrete pavement of the Ohi Container Terminal, the Port of Tokyo, Japan. For the design CBR, a value of 2.5% was employed to suit the uncompacted subsoil reclaimed with dredged sand. Fig.-V3.19 shows a cross-section of the pavement. For the subgrade, crushed stone will be used in a thickness of 50cm, and the surface, intermediate and base layers shall be of bituminous pavement, each 5cm in thickness.

The pavement of the container yards of the Queen Elizabeth Quay Nos. 4 and 5 should have a surface layer and an intermediate layer laid on the existing pavement, each in a thickness of 5cm, as illustrated in Fig.-V.3.20.

3-5 Establishment of Soil Survey System

In order to establish a soil survey system in the Sri Lanka Ports Authority, at least a boring machine and some field test equipments will be necessary. Table-V.3.4 shows a unit of soil survey equipment and their cost.

Table – V.3.1 Specification of Container Crane used in Design

Specification	Container capacity (fully loaded)	31 tons
	Container size	40'0" (12.2 m.)
	Hoist speed	120 f.p.m. (36.6 m.p.m.)
	Main travel	150 f.p.m. (45.7 m.p.m.)
	Cross travel	500 f.p.m. (152.4 m.p.m.)
	Boom hoist (time)	7½ min.
	Track width	50'0" (15.24 m.)
	Overall height (folded boom)	215'0" (65.6 m.)
	Working reach of boom over ship	110'0" (33.5 m.)
	Maximum wheel loading, quay leg	34.5 tons/wheel
	Maximum wheel loading, shore leg	30.6 tons/wheel
	Crane weight	506 tons
	Rating: This crane is provided with Class 4, extra heavy duty equipment.	

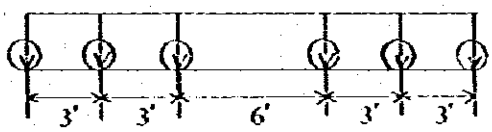


Table – V.3.2 Specification of Container Cranes Used in Japan

Berth			No. 1	No. 3	No. 4	No. 6	No. 8	No. 8	No. 5	No. 6	No. 7
Crane No.			OC11	OC31	OC41	OC61	OC81	OC82	HC51	HC61	HC71
Crane Type			High speed, rope trolley	High speed, rope trolley	Semi-rope trolley	Flexible boom, high speed, semi-rope trolley	Flexible boom, rope trolley	Flexible boom, high speed, semi-rope trolley	High speed, rope trolley	Semi-rope trolley	Semi-rope trolley
Completion date			Jun. 1975	Apr. 1975	Feb. 1974	Mar. 1973	Mar. 1972	Oct. 1972	May 1974	Jan. 1971	May 1970
Lift load (t)			45.0	50.0	45.0	50.0	44.0	49.6	43.5	39.5	39.5
Lift load (t)			30.5 35.0 (Hatch cover)	30.5 35.6 (Hatch cover)	30.5 35.6 (Hatch cover)	30.5 35.6 (Hatch cover)	30.5 35.5 (Hatch cover)	30.5 35.6 (Hatch cover)	30.5	30.5	30.5
Crane gauge (m)			2.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Rail span (m)			16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
Traversing (m)	Trolley overall traversing distance		62.5	67.0	67.0	67.0	67.0	67.0	61.0	57.0	57.0
	Out reach (from rail on sea side)		35.5	35.0	35.0	35.0	35.0	35.0	35.0	33.5	33.5
	Back reach (from rail on land side)		11.0	16.0	16.0	16.0	16.0	16.0	10.0	7.5	7.5
Lift (m)	Overall lift		37.0	37.0	37.0	37.0	37.0	37.0	38.6	33.5	33.5
	Overall surface		25.0	25.0	25.0	25.0	25.0	25.0	25.0	21.7	21.7
	Below rail surface		12.0	12.0	12.0	12.0	12.0	12.0	13.6	11.8	11.8
Effective interval within legs			16.0	16.0	16.0	16.0	16.0	16.0	16.0	14.5	14.5
Effective height beneath bridge beam (m)			9.0	9.0	9.0	9.5	9.0	9.5	10.7	9.0	9.0
Power (cable winding)			A.C 3000V 50Hz	A.C 3000V 50Hz	A.C 3000V 50Hz	A.C 3000V 50Hz	A.C 3000V 50Hz	A.C 3000V 50Hz	A.C 550V 50Hz	A.C 550V 50Hz	A.C 550V 50Hz
Generator drive motor output (KW)			A.C 500	3φ Transformer 750 KVA	3φ Transformer 500 KVA	3φ Transformer 750 KVA	A.C 350 (75% ED)	A.C 500 (60% ED)	3φ Transformer 800 KVA	A.C 400 (Continuous)	A.C 400 Continuous)
Generator combination			Winding and traveling / Traversing and elevation	Winding and traveling / Traversing and elevation	Winding and traveling / Traversing and elevation	Winding and traveling / Traversing and elevation	Winding and traveling / Traversing and elevation	Winding and traveling / Traversing and elevation	Winding and traveling / Traversing and elevation	Winding and traveling / Traversing and elevation	Winding and traveling / Traversing and elevation
Generator output (KW.A)			405 / 100	SCR500A / SCR300A	– / SCR150A	– / SCR300A	250 / 100	400 / 110	–	290 / 110	290 / 110
Motor output	Winding (Rated)		D.C 370 (Continuous)	D.C 370 Continuous)	D.C 220 (Continuous)	D.C 370 (Continuous)	D.C 220 (Continuous)	D.C 185 × 2 (Continuous)	D.C 185 × 2 (Continuous)	D.C 125 × 2 (Continuous)	D.C 125 × 2 (Continuous)
	Traversing (Rated)		D.C. 80 (Continuous)	D.C 45 × 2 (Continuous)	D.C 25 × 2 (Continuous)	D.C 45 × 2 (Continuous)	D.C 50 (60% ED)	D.C 100 (40% ED)	D.C 75 (Continuous)	D.C 25 × 2 (Continuous)	D.C 25 × 2) (Continuous)
	Traversing (Rated)		D.C 12.5 × 8 (30 mins)	D.C 15 ×8 (30 mins)	D.C 15 × 8 (30 mins)	D.C 15 × 8 (30 mins)	D.C 12.5 × 8 (30 mins)	D.C 12.5 × 8 (30 mins)	D.C 30 × 4 (60 mins)	D.C 20 × 4 (30 mins)	D.C 20 × 4 (30 mins)
	Elevation (Rated)		D.C 75 (60 mins)	D.C 75 (30 mins)	D.C 7.5 (30 mins)	D.C 95 (30 mins)	D.C 90 (30 mins)	D.C 90 (30 mins)	D.C 75 (30 mins)	D.C 67 (30 mins)	D.C 67 (30 mins)
Speed (m/min)	Winding Total load/No load		50/120	50/120	35.5/90	50/120	35.5/90	50/120	50/120	35.5/71	35.5/71
	Traversing		150	150	125	150	125	150	150	125	125
	Traveling		45	45	45	45	45	45	45	45	45
	Elevation (min/cycle)		8	8	8	8	8	8	8	8	8
Number of wheels		Quay side	8 × 2	8 × 2	8 × 2	8 × 2	8 × 2	8 × 2	8 × 2	6 × 2	6 × 2
		Shore side	8 × 2	8 × 2	8 × 2	8 × 2	8 × 2	8 × 2	8 × 2	6 × 2	6 × 2
Maximum wheel load (t/wheel)	In operation	Quay side	29.6	37.7	30.1	38.2	33.7	38.1	30.3	37.1	37.4
		Shore side	27.0	29.6	28.2	28.5	21.8	27.6	32.4	28.9	26.4
	In storm	Quay side	31.6	30.8	26.4	35.9	33.3	30.4	32.9	30.2	30.5
		Shore side	41.0	46.0	45.3	43.6	35.7	43.7	45.2	43.8	42.5
Traveling range (m)			270	400	400	450	300	300	150	200	200
Crane weight (t)			550	615	575	660	583	635	631	521	510
Traveling rail height Quay side/Shore side (m)			4.0 / 4.0	4.02 / 4.18	4.02 / 4.18	4.02 / 4.18	4.02 / 4.18	4.02 / 41.8	3.82 / 3.98	3.82 / 3.98	3.82 / 3.98
Operating room mounting system			Trolley suspension	Trolley suspension	Trolly suspension	Trolly suspension	Trolly suspension	Trolly suspension	Trolly suspension	Trolly Suspension	Trolly suspension
Remarks			With steady rest Telescopic spreader, 2 Spreader truck, 2	With steady rest Telescopic spreader, 1 Spreader truck, 1	20ft Spreader, 1 40ft Spreader, 1	With steady rest 20ft Spreader, 1 40ft Spreader, 1	20ft Spreader 2 40ft Spreader, 2 Spreader truck, 3	With steady Suspension fixture, 1	With steady rest Sea side rocking leg Stacking frame	Spreader 20' × 1 25' × 1 Stacking frame With receptacle	Spreader 20' × 2 40' × 2

Source: Keihin (Tokyo Bay) Port Development Authority

Table – V.3.3 Specification of Tie Wire Rope

Diameter (mm)	Standard cross-section area (mm^2)	Ultimate strength (extension) (t)	Weight (kg/m)
52	1,380	221	12.7

Table -- V.3.4 Soil Investigation Equipments and Costs

(Unit: US$)

No.	Articles	Quantity	Price
1	Trailer mounted drill for geological survey Capacity; 180 m with 40.5 mm drill rods 160 m with AW drill rods Power unit; Water-cooled diesel engine, hand starting, 4 cycle, 9 PS/2,200 rpm Bit speeds; 135 – 270 – 560 rpm Mast, Trailer, Rod rack	1 set	16,000
2	Mud mixer with power unit	1 set	1,680
3	Drill rods with coupling	1 set	650
4	Soil sampling equipment	1 set	1,200
5	Undisturbed soil sampler	1 set	700
6	Guide pipe & starting bit	1 set	600
7	Lowering & lifting equipment	1 set	450
8	Coring equipment (Size 86)	1 set	400
9	Coring equipment (Size 66)	1 set	800
10	Standard penetration testing equipment	1 set	750
11	Fishing equipment	1 set	550
12	Miscellaneous tools	1 set	850
	Total		24,630

Fig. – V.3.1 Cylinder

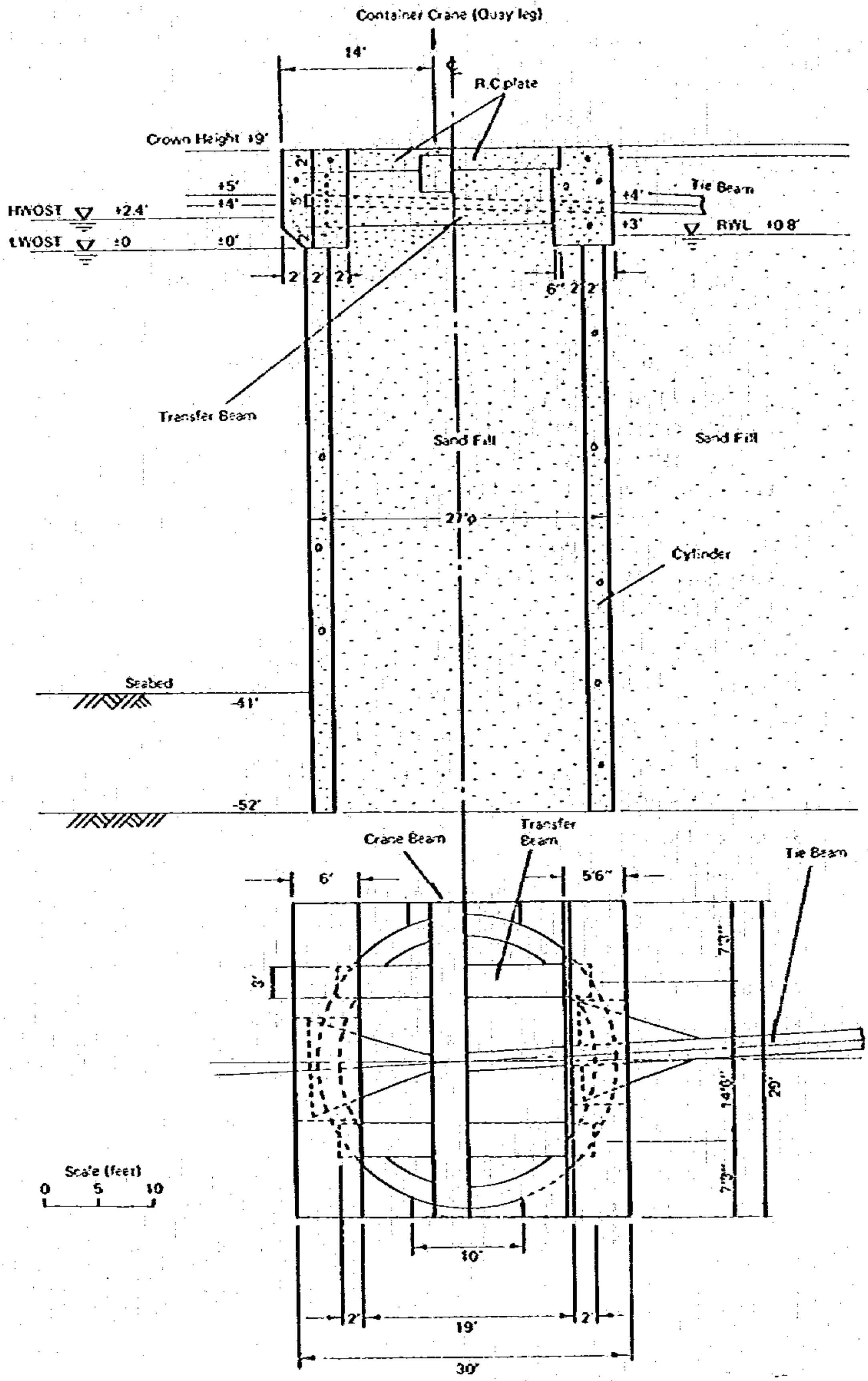


Fig. – V.3.2 Segment

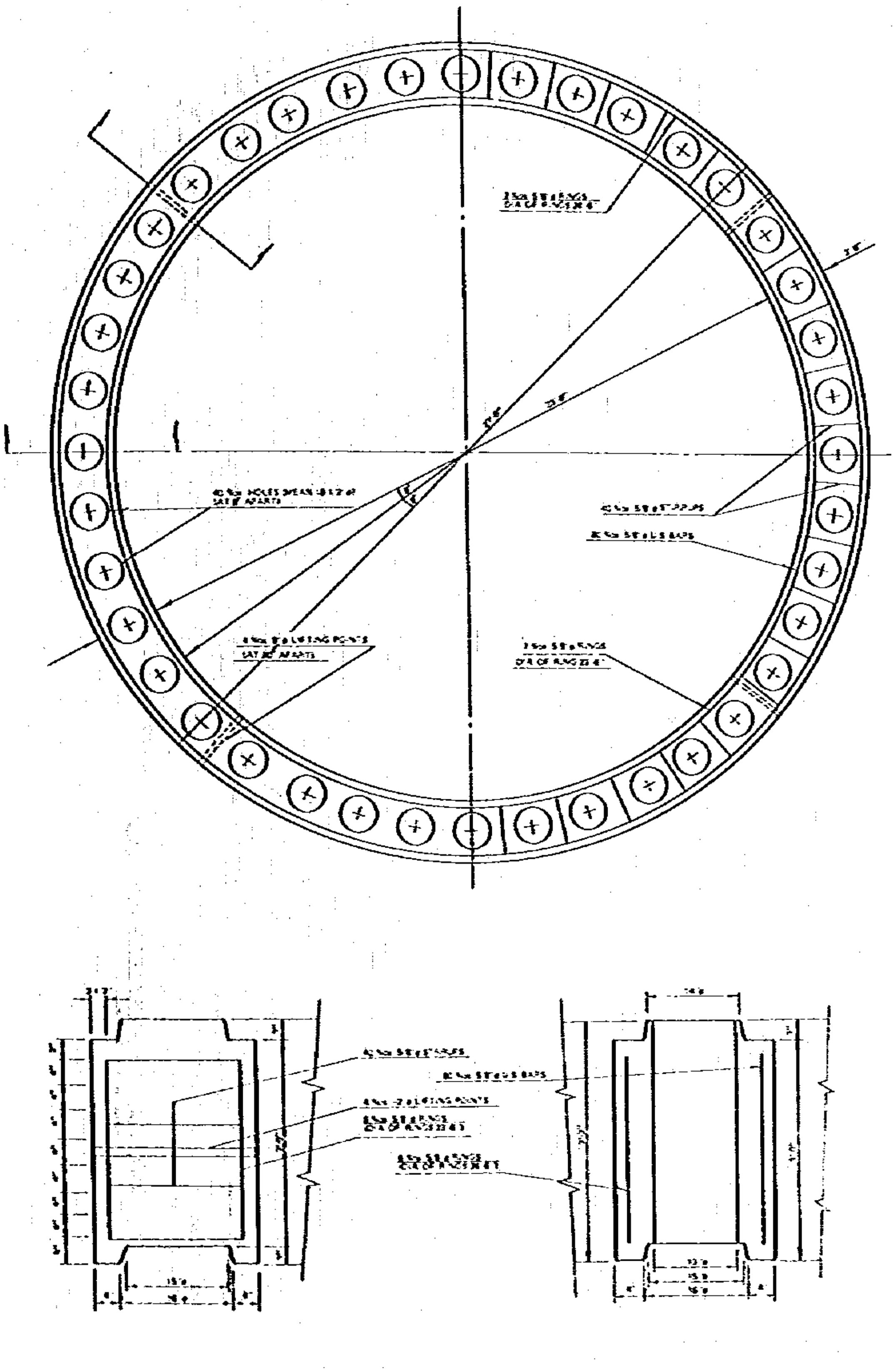


Fig. – V.3.3 Crane Beam

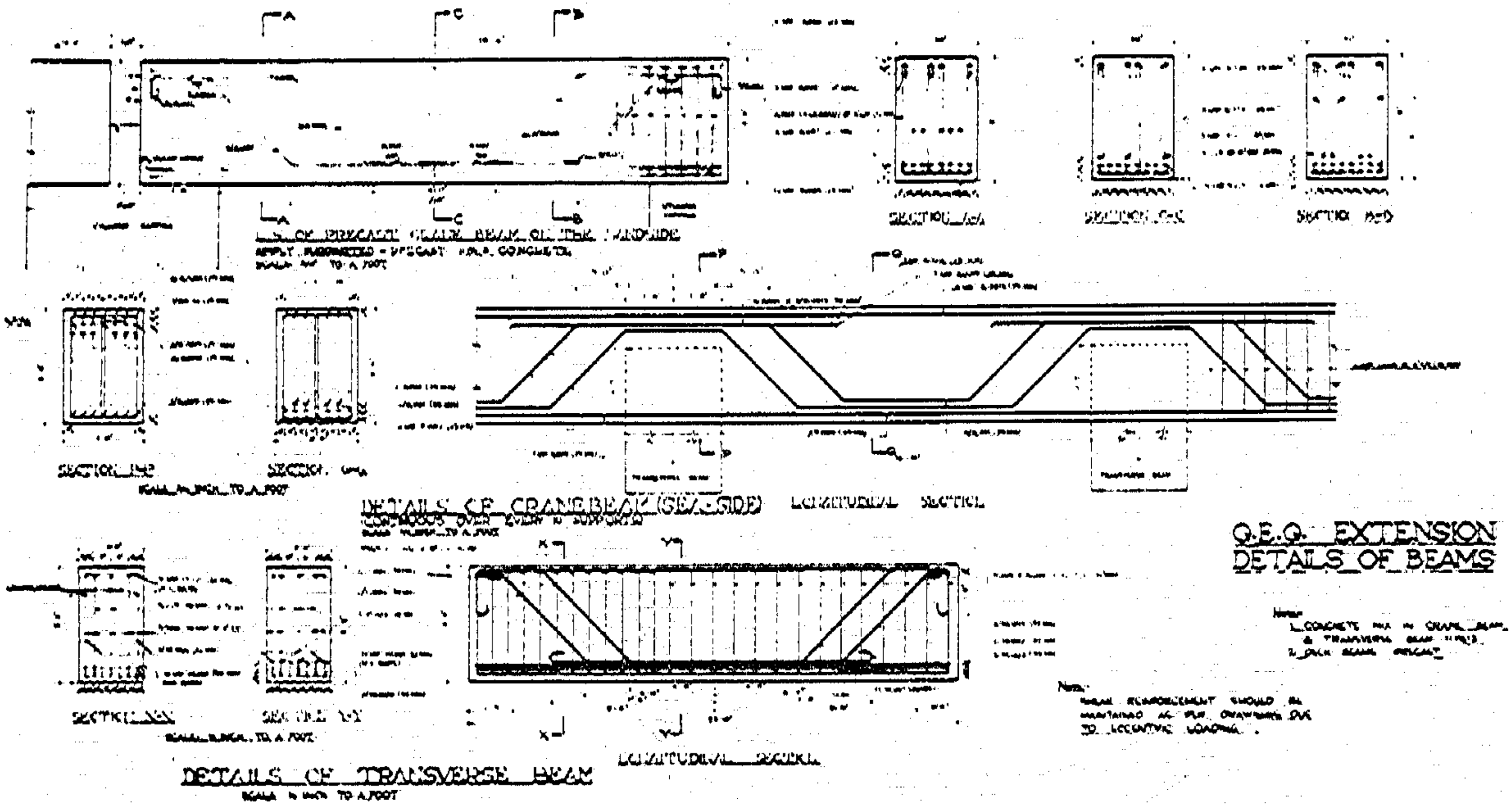


Fig. — V.3.4 Tie Beam

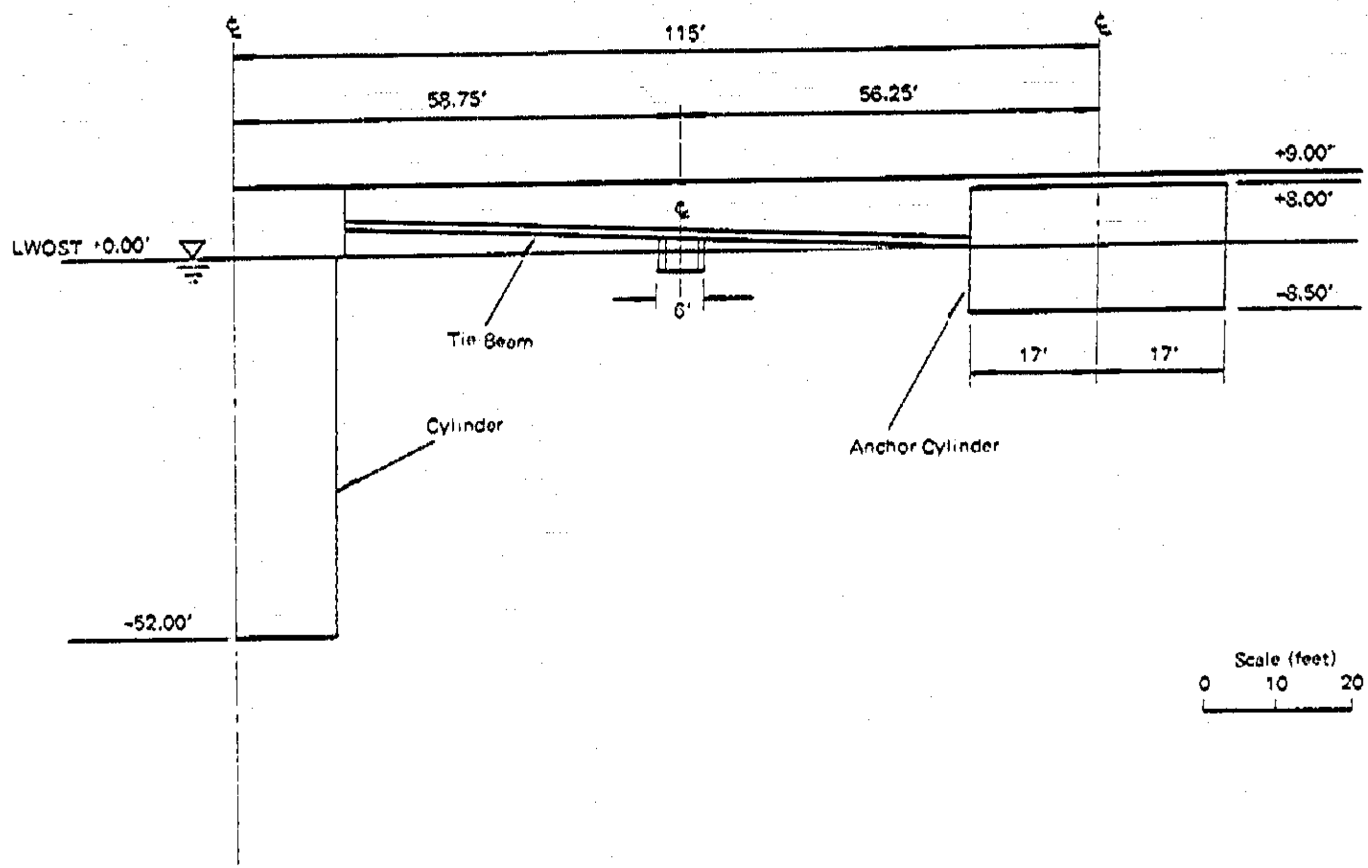


Fig. – V.3.5 Anchor Cylinder

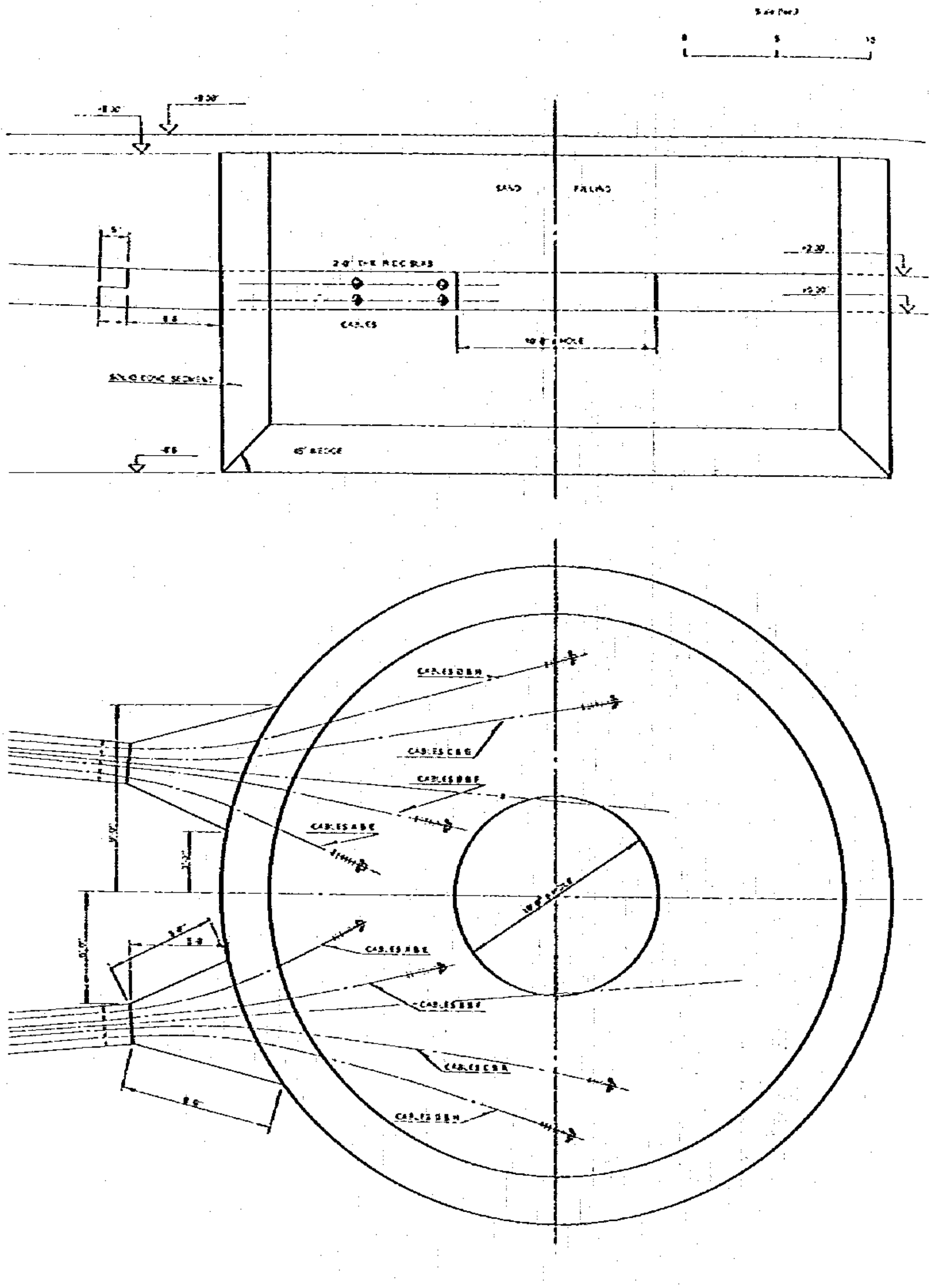


Fig. – V.3.6 N-Value around the Cylinder Bottom

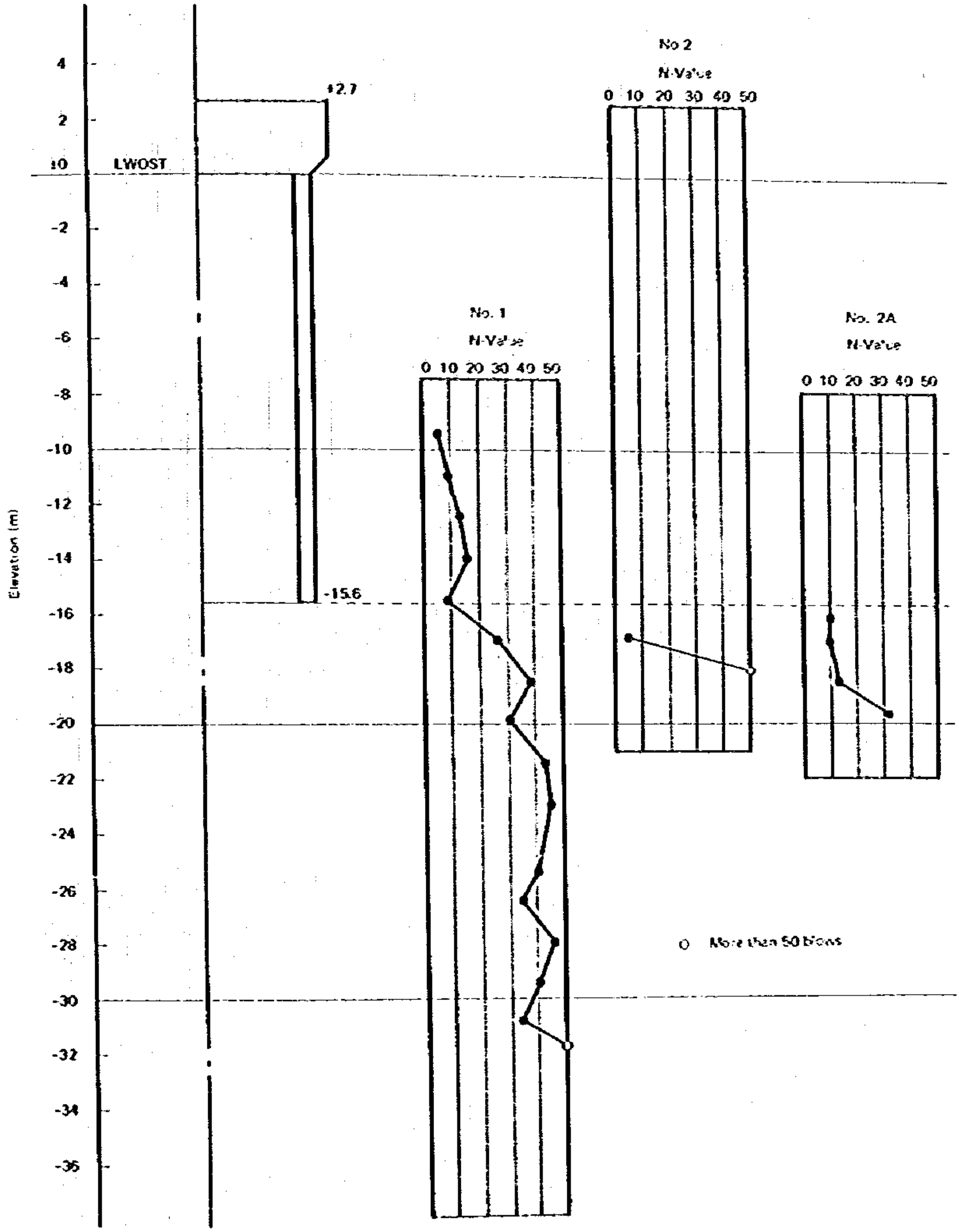


Fig. – V.3.7 Crane Weight versus Wheel Load during Operation

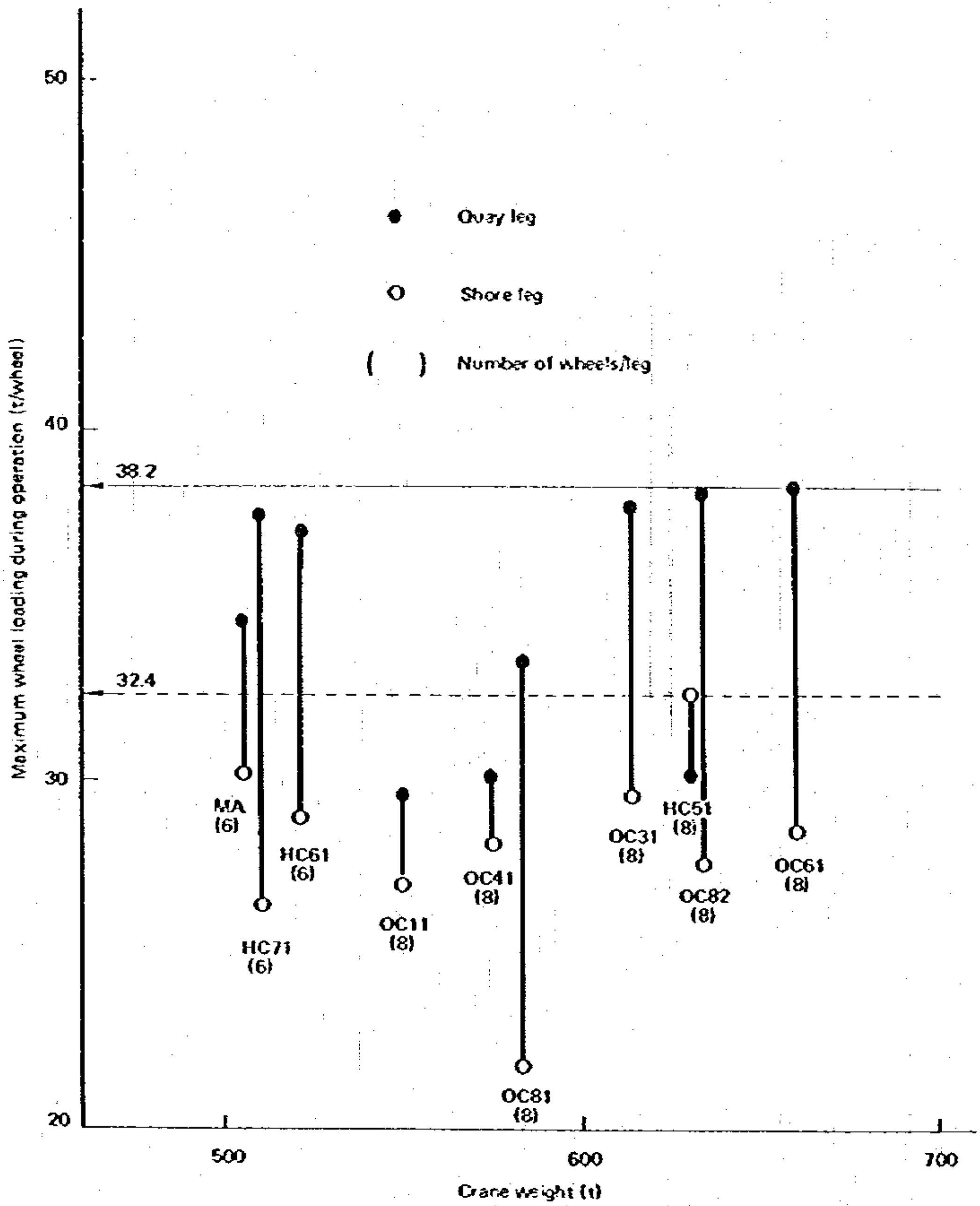


Fig. -- V.3.8 Crane Weight versus Wheel Load during Storm

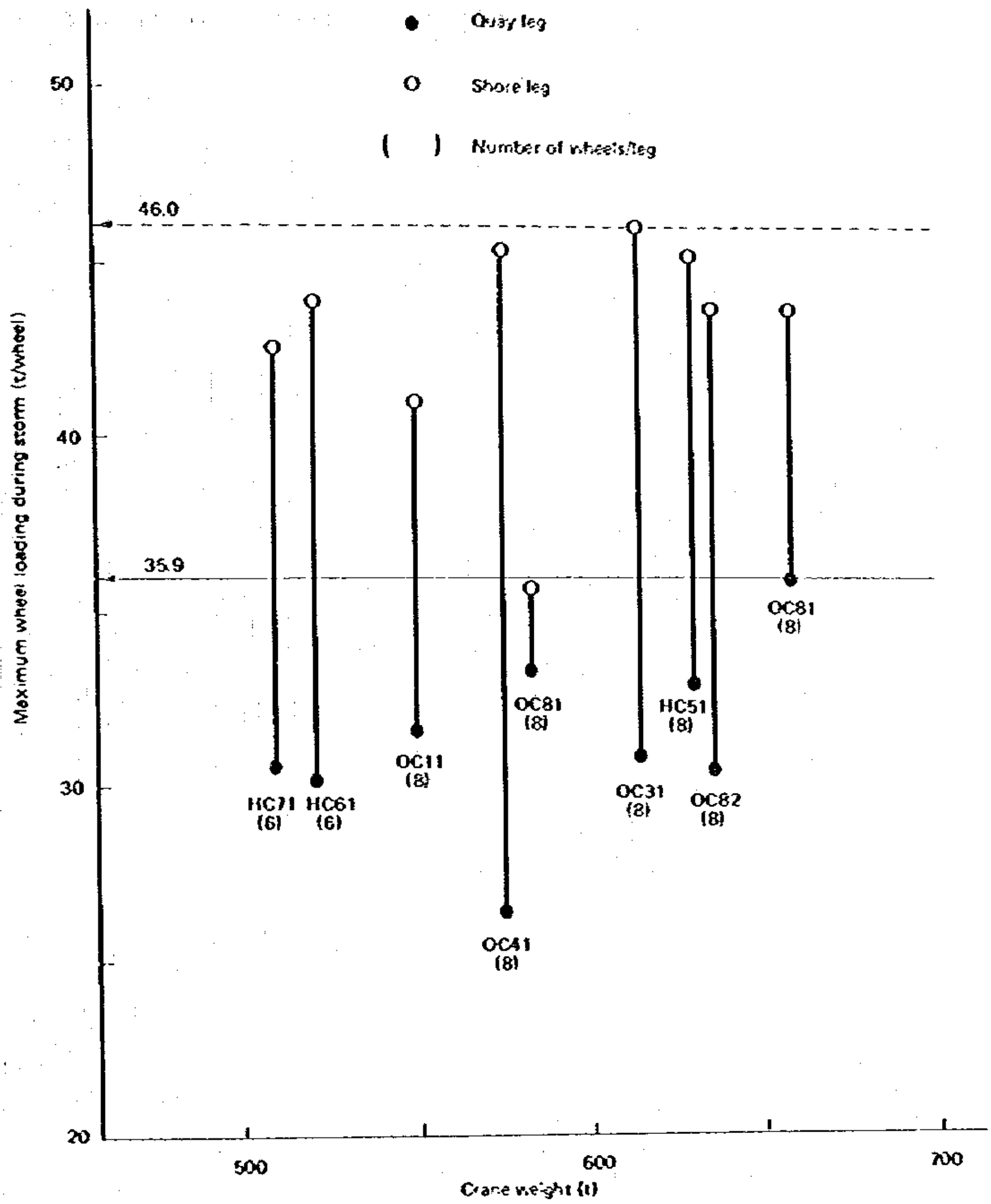


Fig. -- V.3.9 Crane Wheel Load versus Toe Pressure

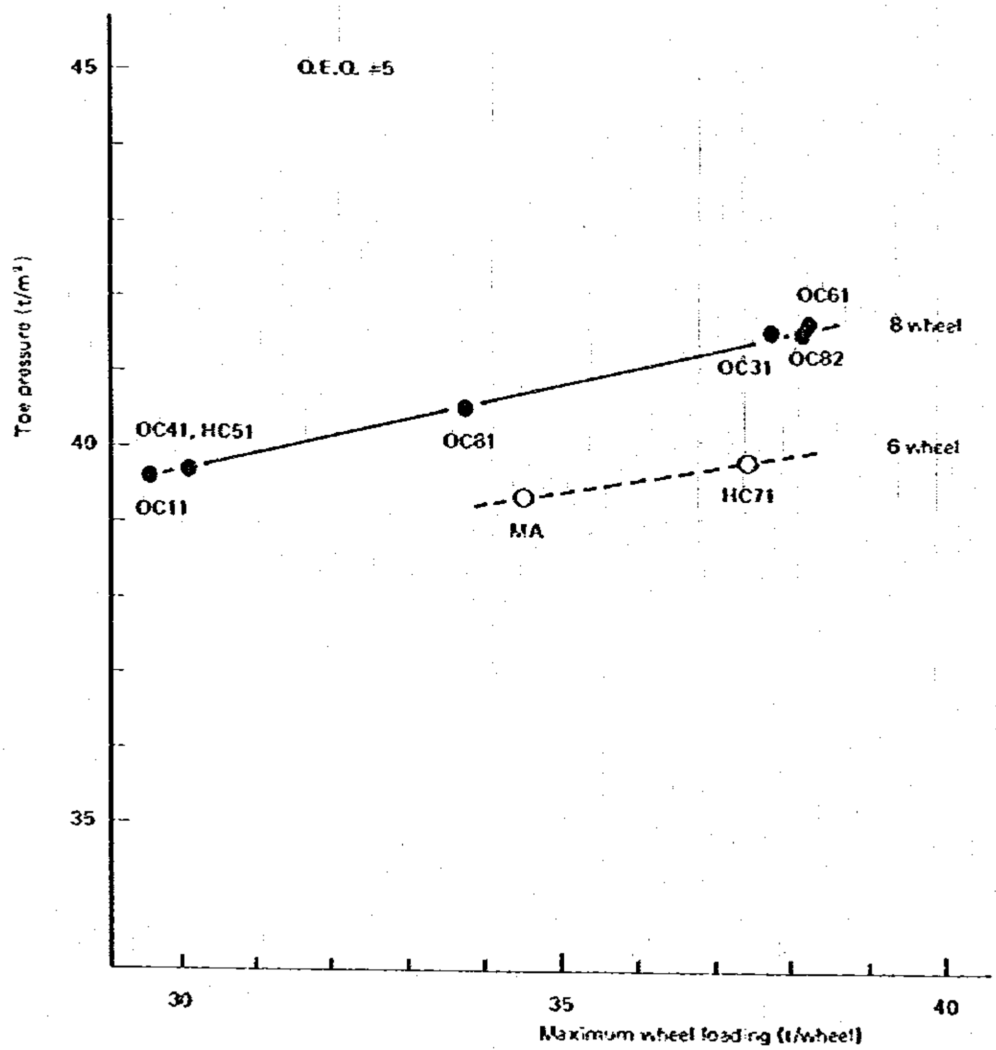


Fig. – V.3.10 Influence Value

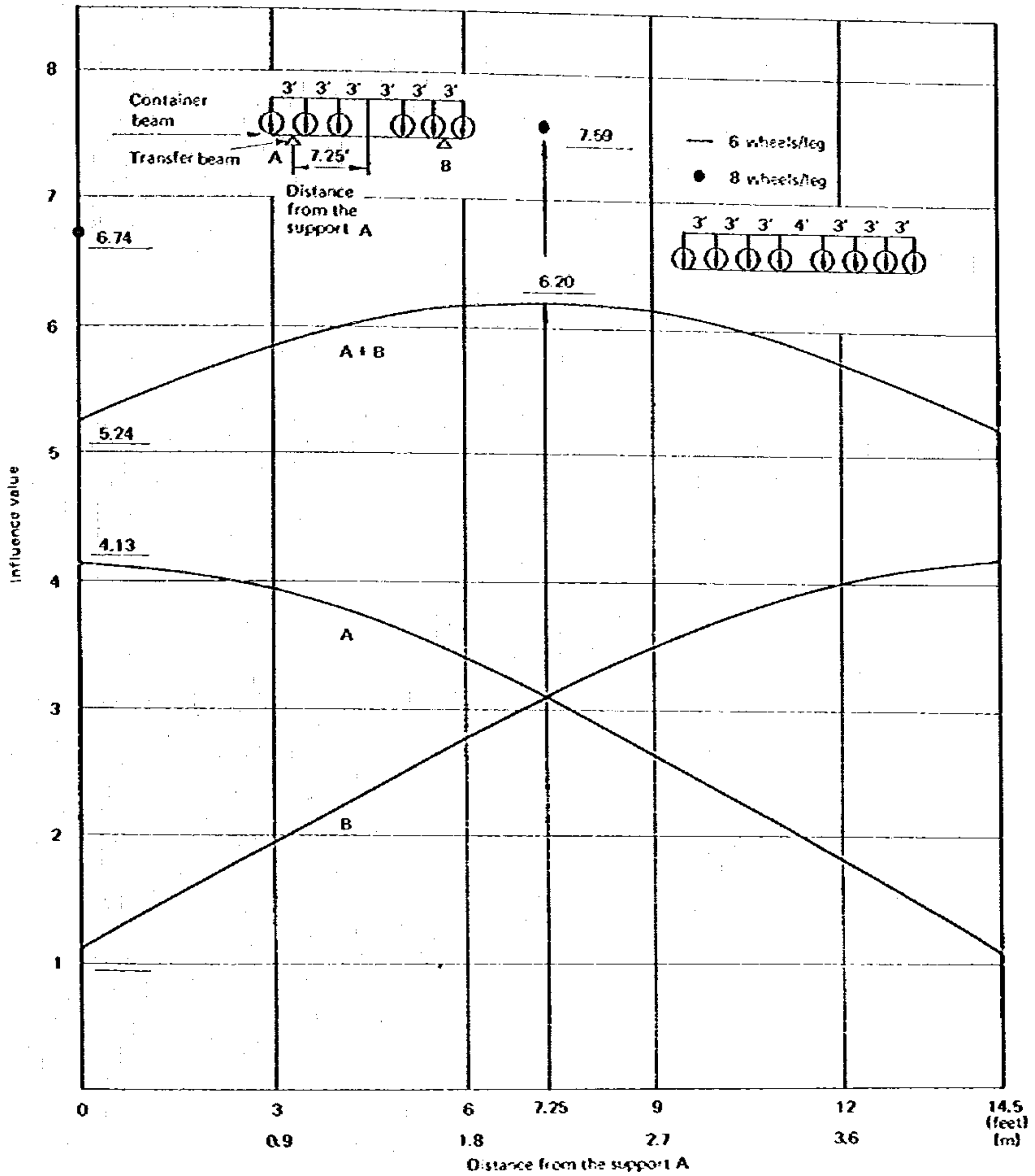


Fig. – V.3.11(a) Allowable Bearing Capacity versus N-Value (Clay)

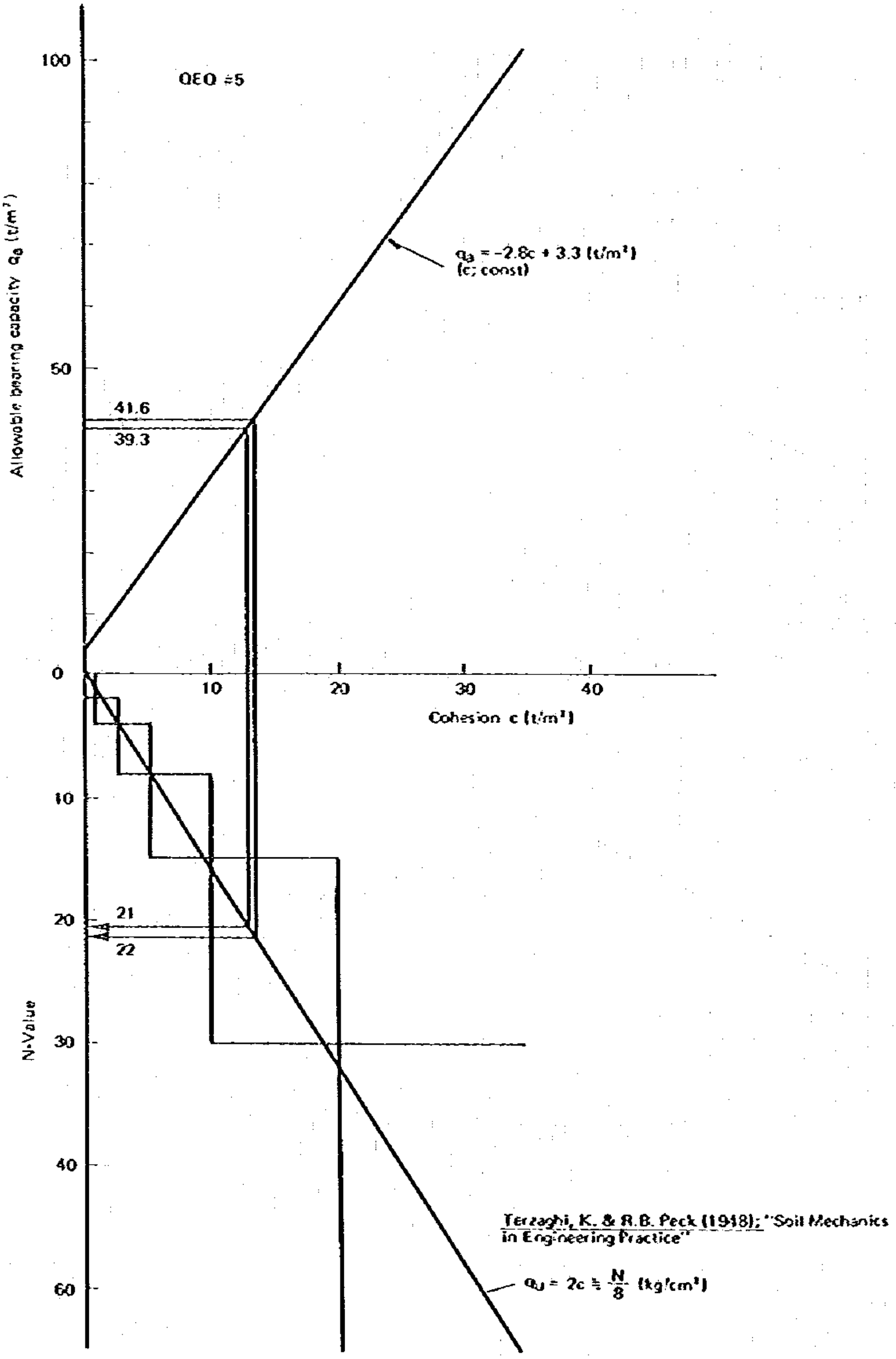


Fig. – V.3.11(b) Allowable Bearing Capacity versus N-Value (Sand)

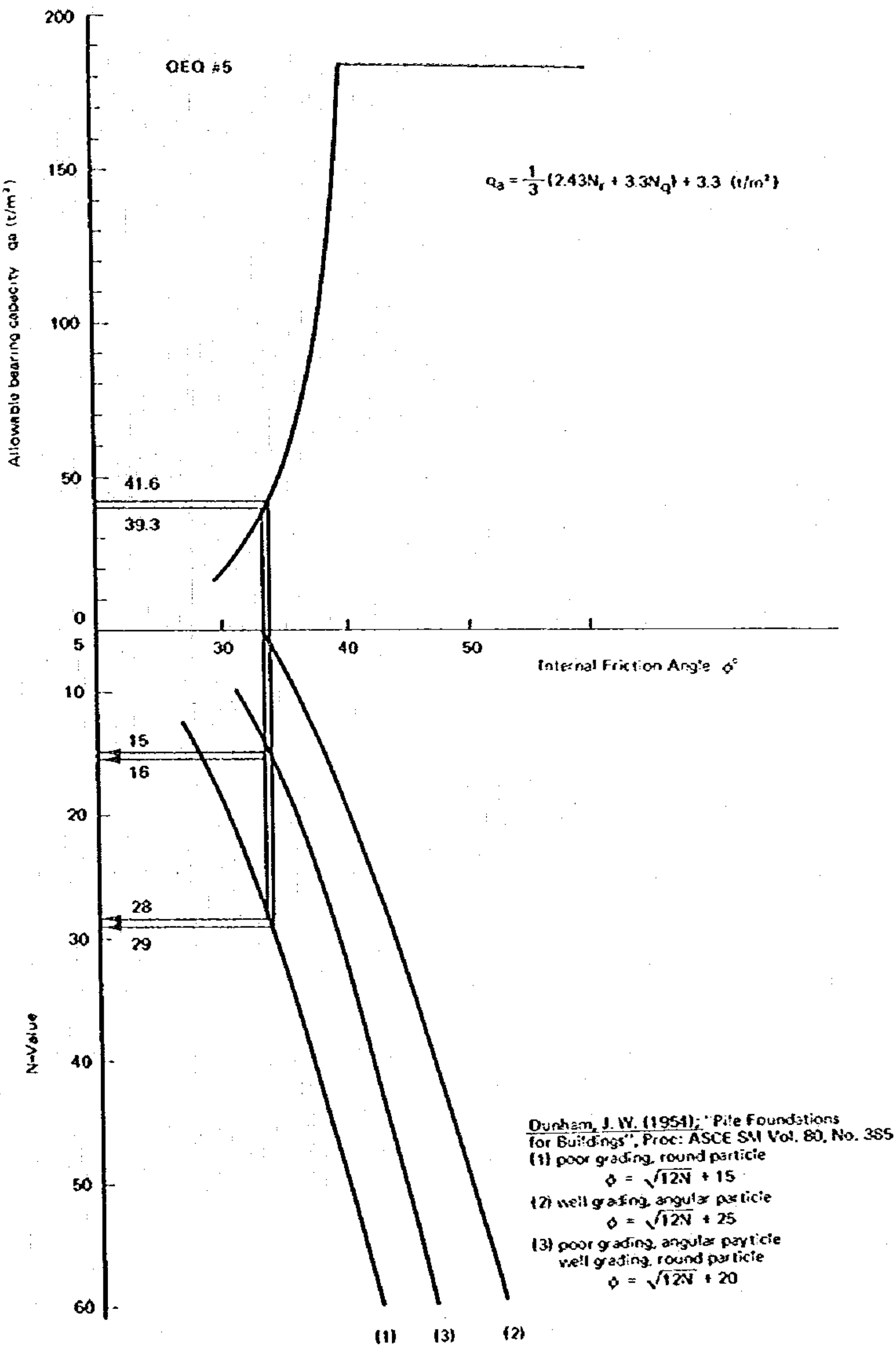


Fig. – V.3.12(a) Cross-section of Cylinder Improvement

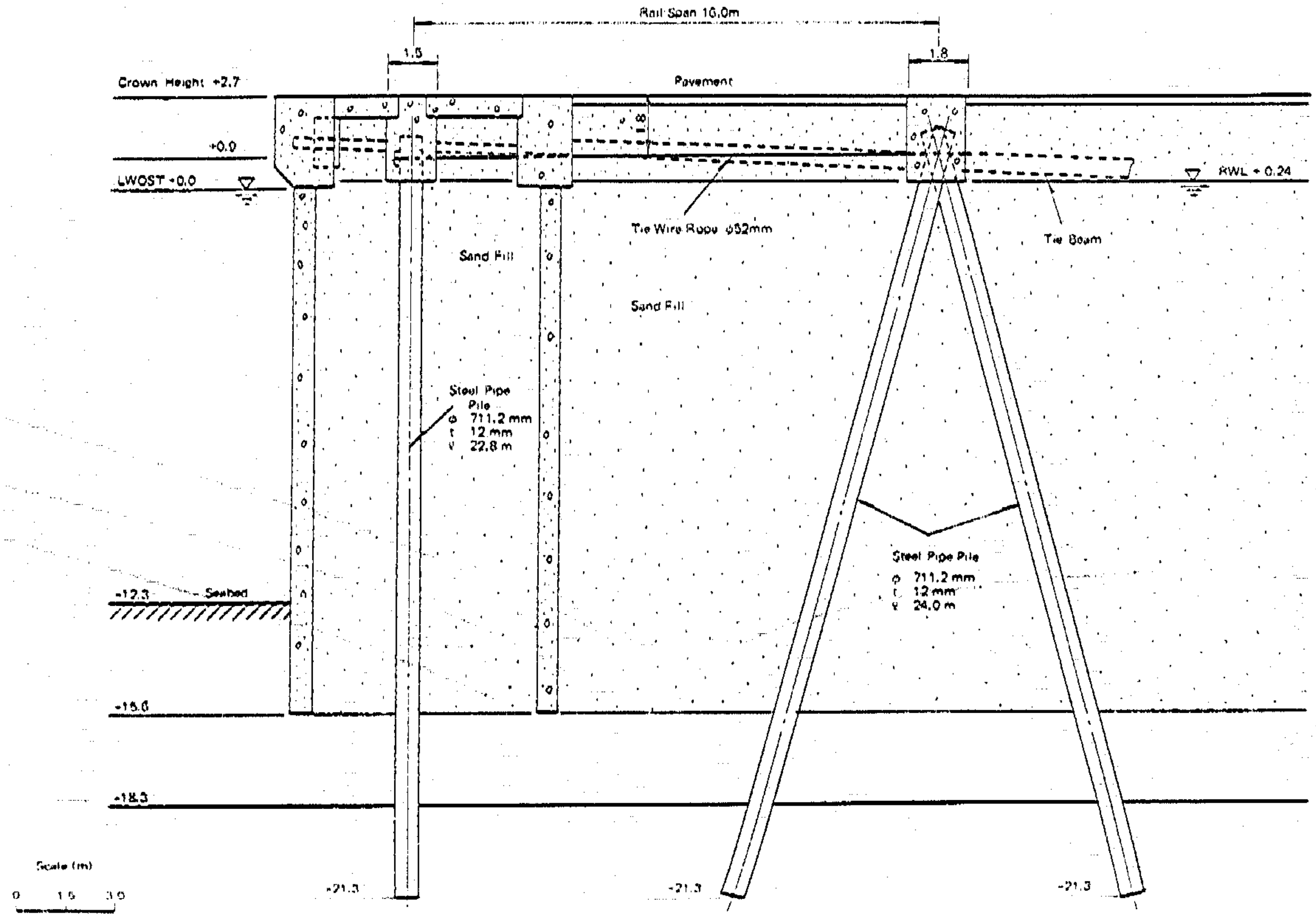


Fig. – V.3.12(b) Plane of Cylinder Improvement

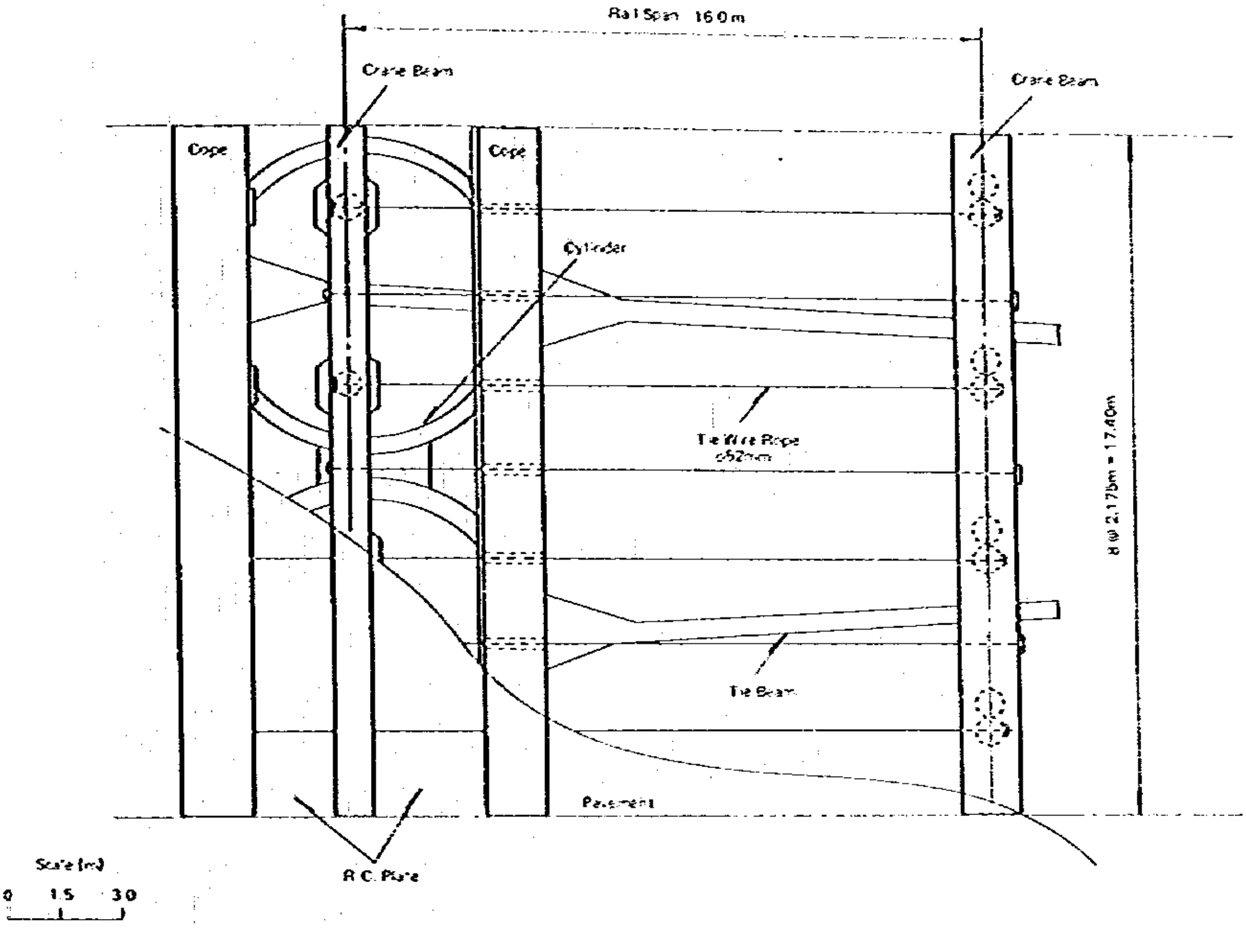


Fig. – V.3.13 Block Work

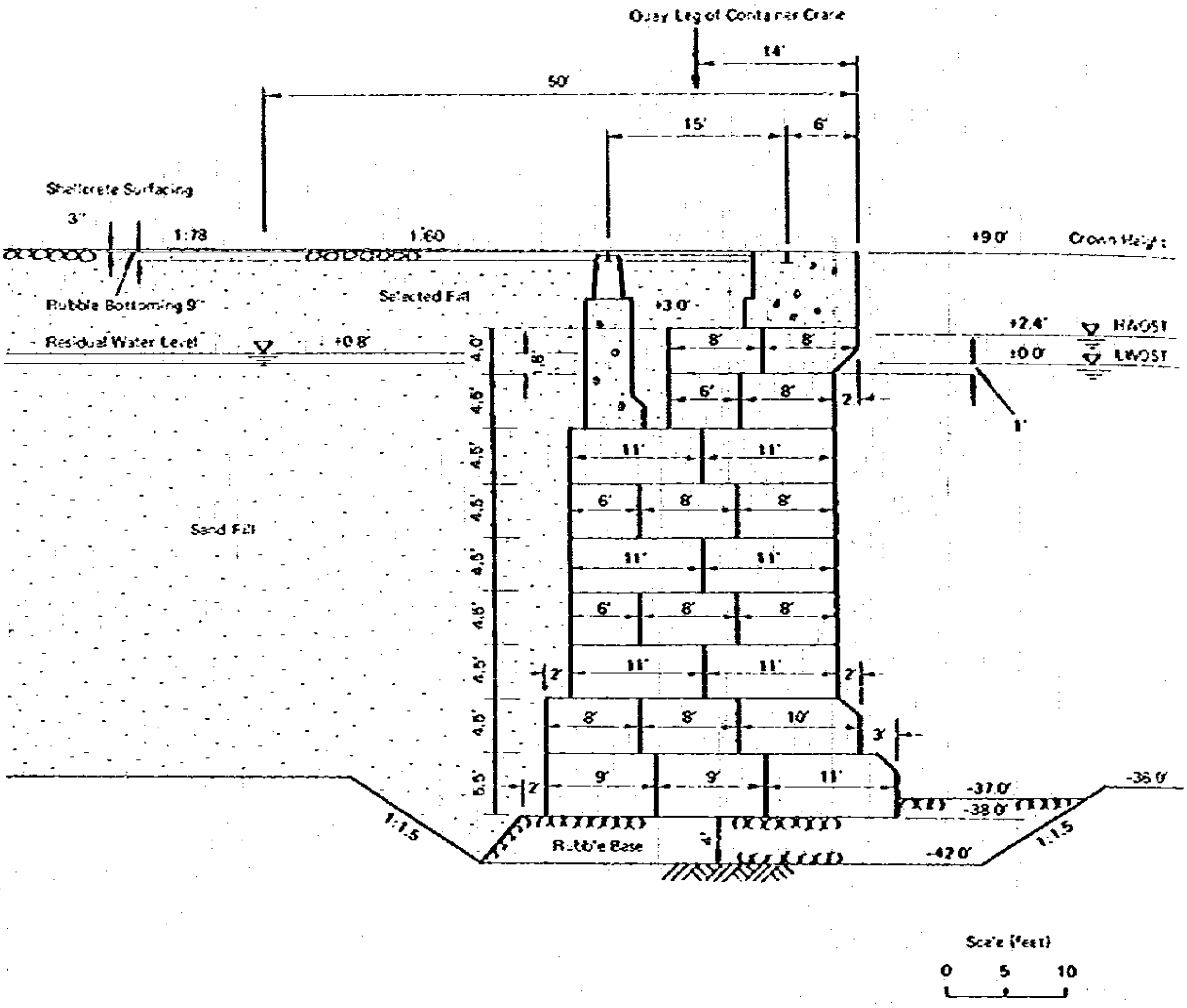


Fig. – V.3.14 Crane Wheel Load versus Reactions of Foundation

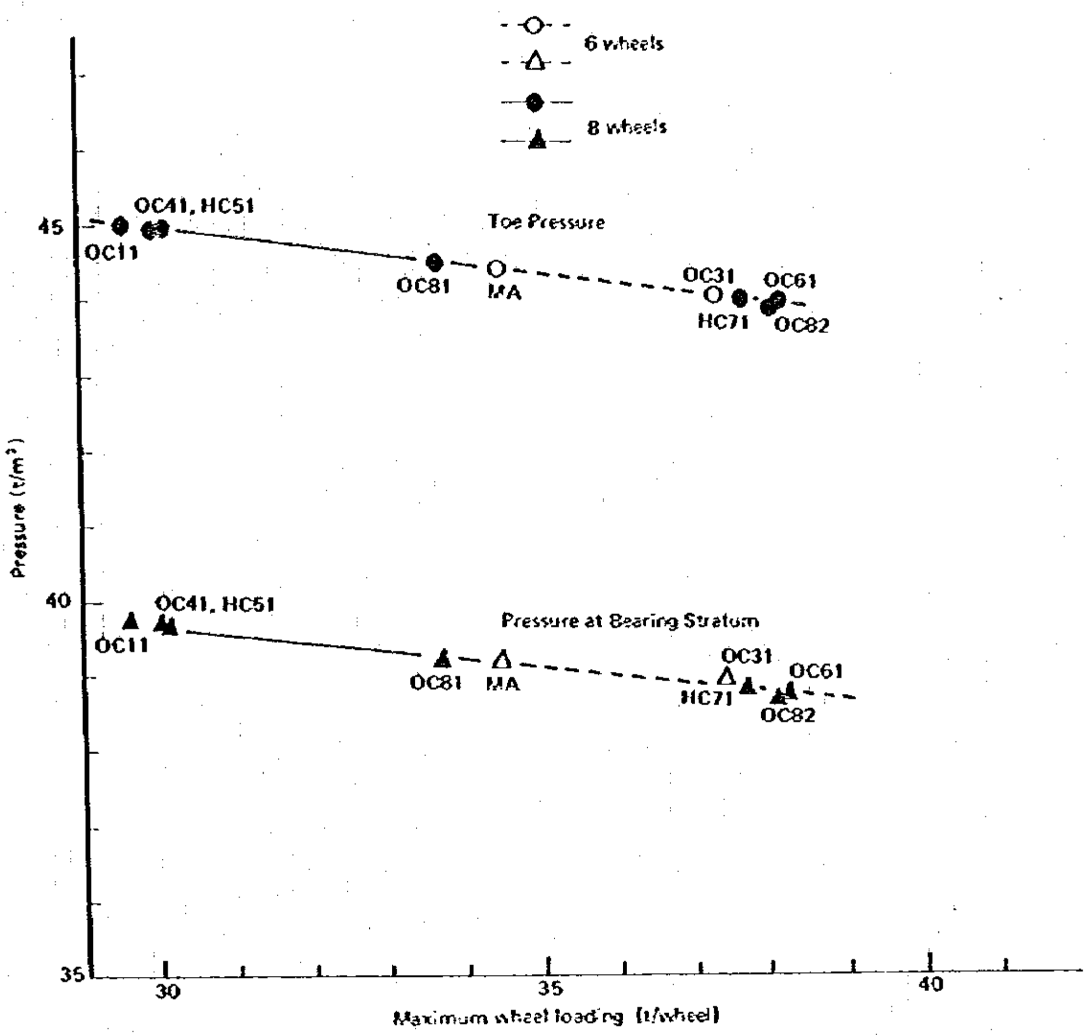


Fig. – V.3.15(a) Allowable Bearing Capacity versus N-Value (Clay)

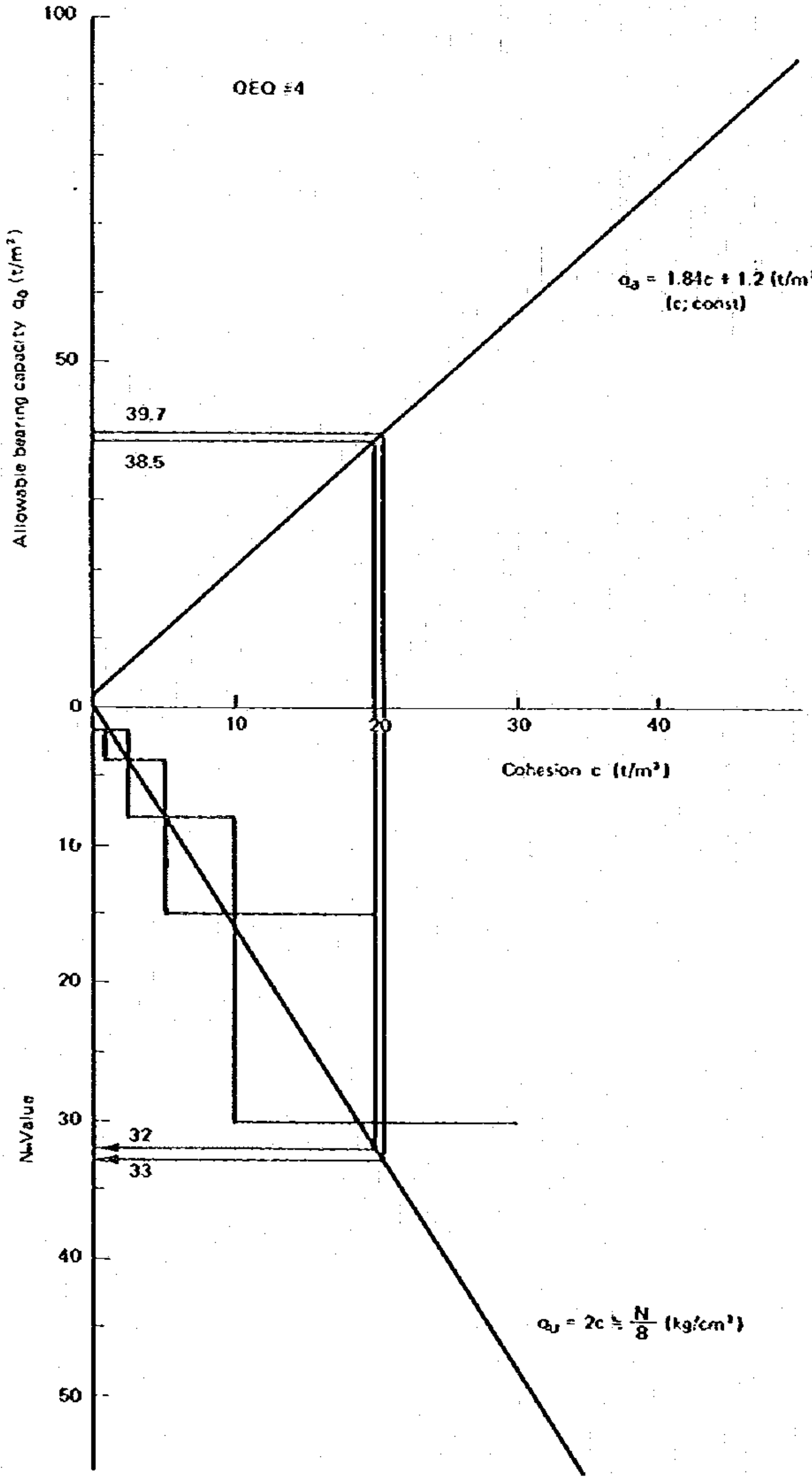


Fig. – V.3.15(b) Allowable Bearing Capacity versus N-Value (Sand)

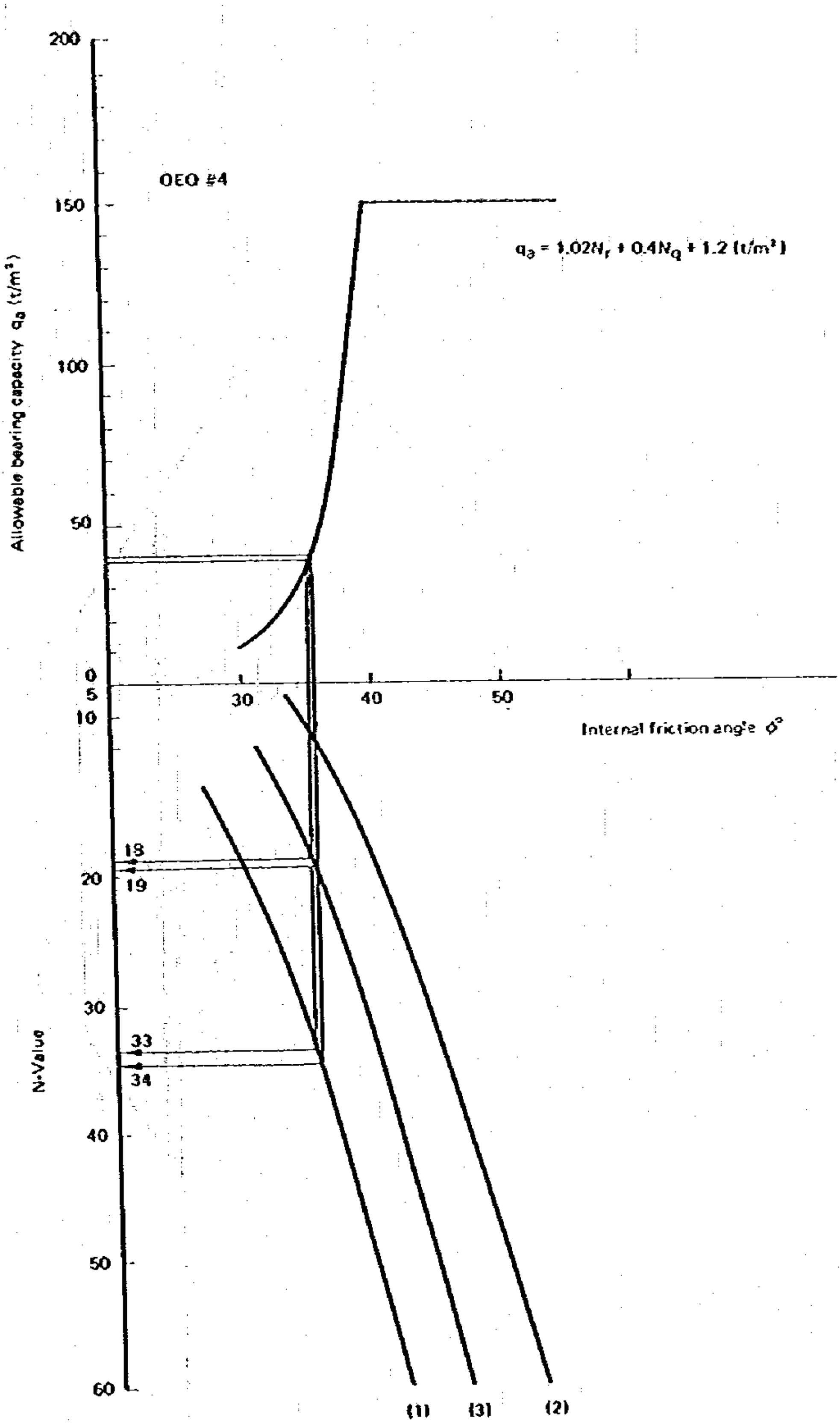


Fig. – V.3.16(a) Cross-section of Gravity-Type Caisson Quaywall (–12m)

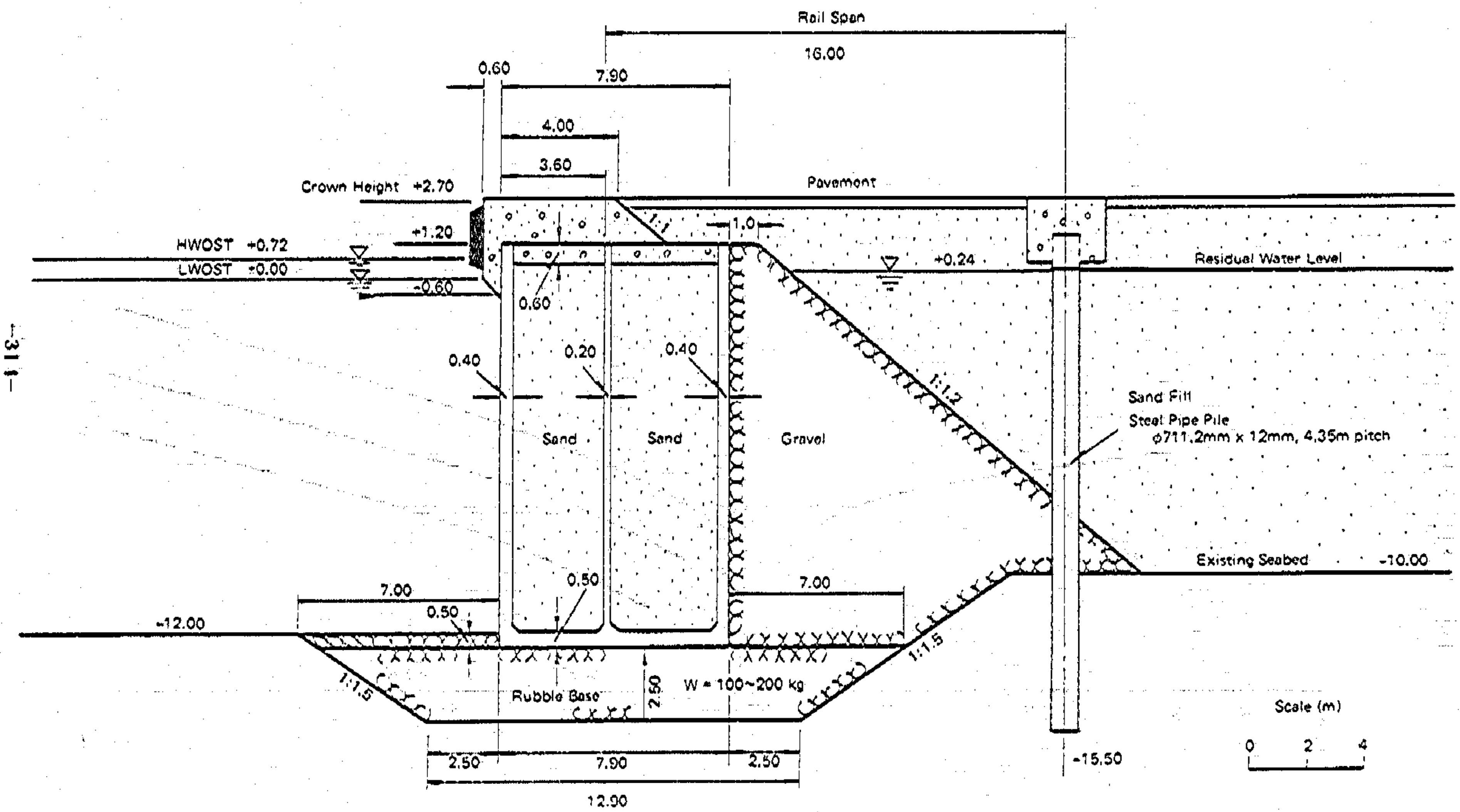


Fig. — V.3.16(b) Plane of Gravity-Type Caisson Quaywall (-12m)

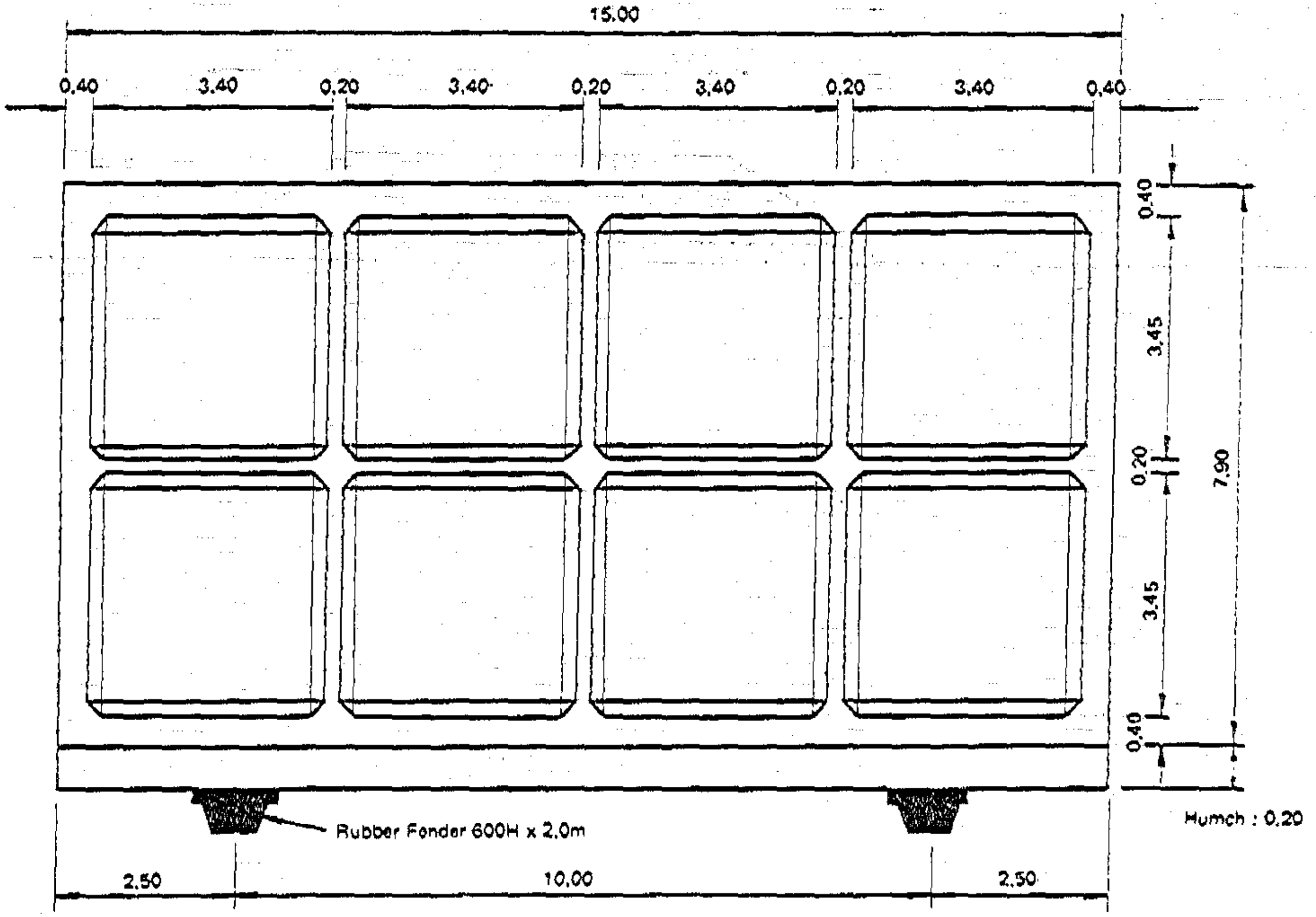


Fig. – V.3.17(a) Cross-section of Gravity-Type Caisson Bulkhead (-10m)

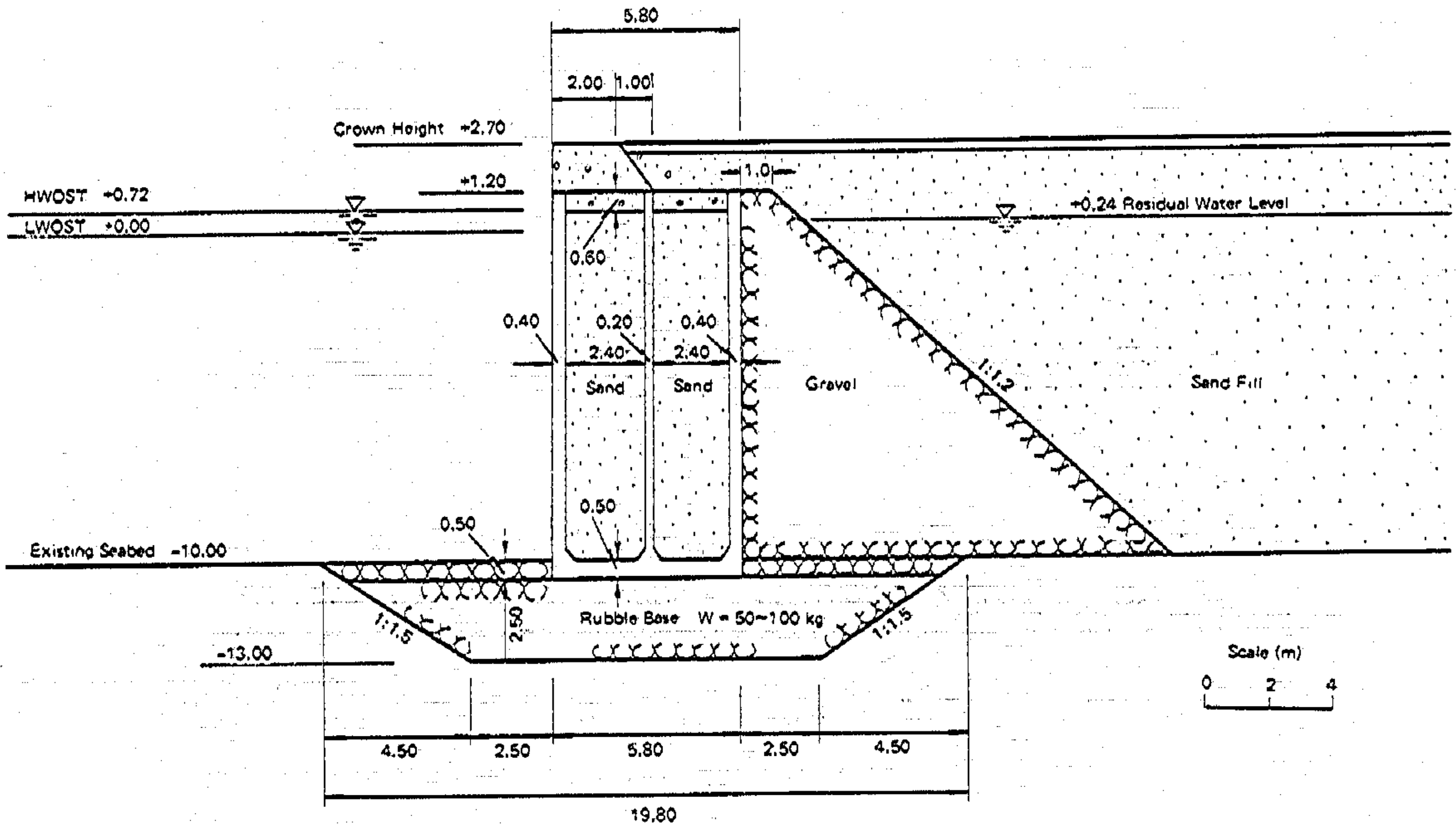


Fig. – V.3.17(b) Plane of Gravity-Type Caisson Bulkhead (-10m)

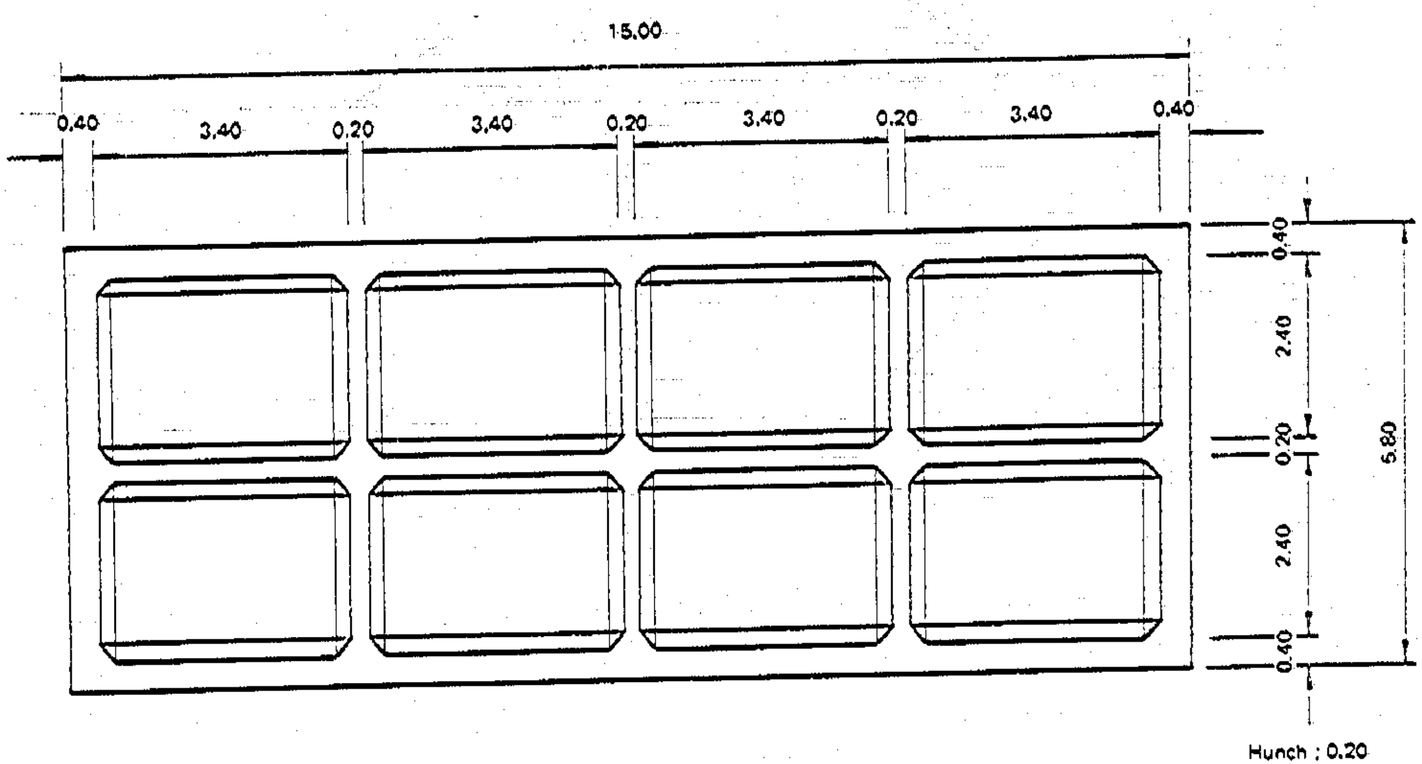


Fig. – V.3.18(a) Cross-section of Gravity Type Caisson Bulkhead (-7.5m)

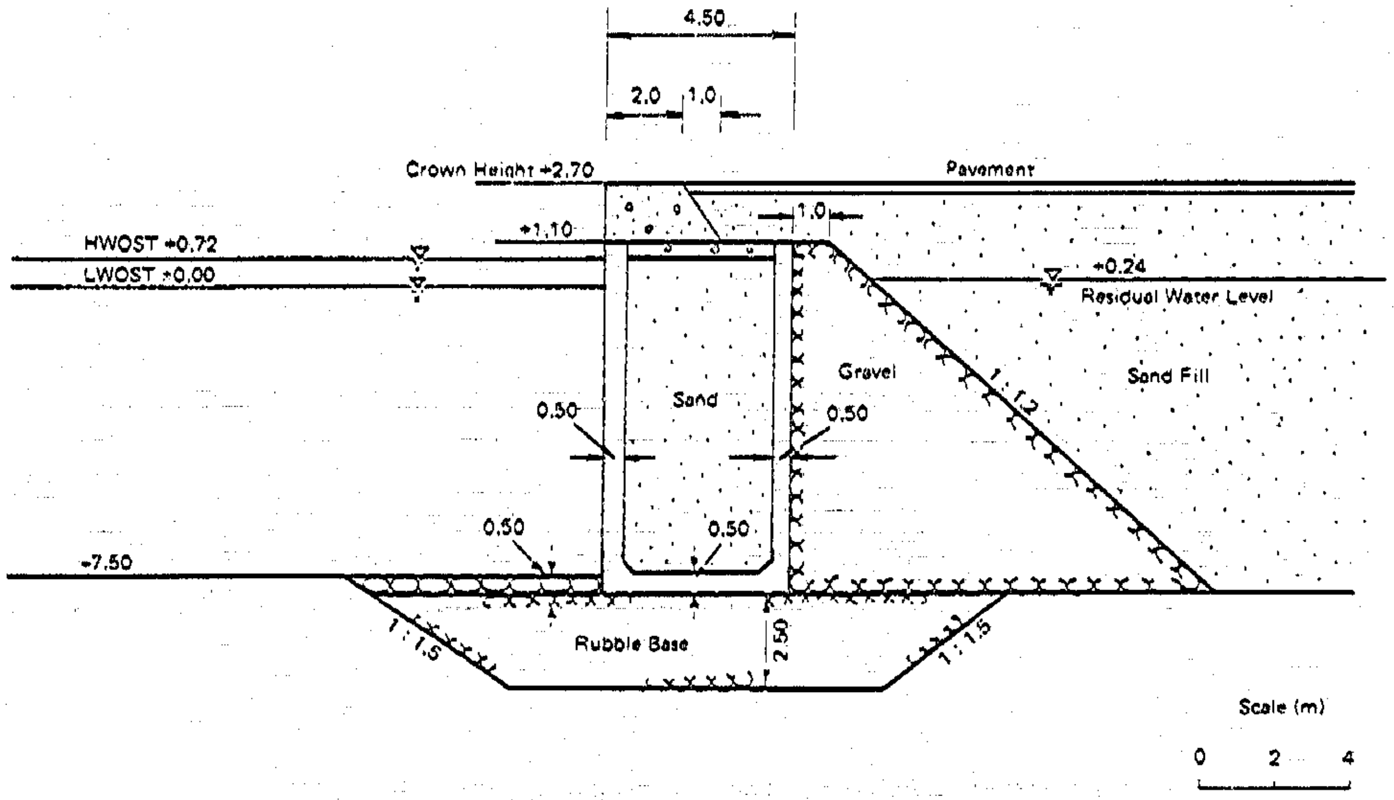


Fig. – V.3.18(b) Plane of Gravity-Type Caisson Bulkhead (–7.5m)

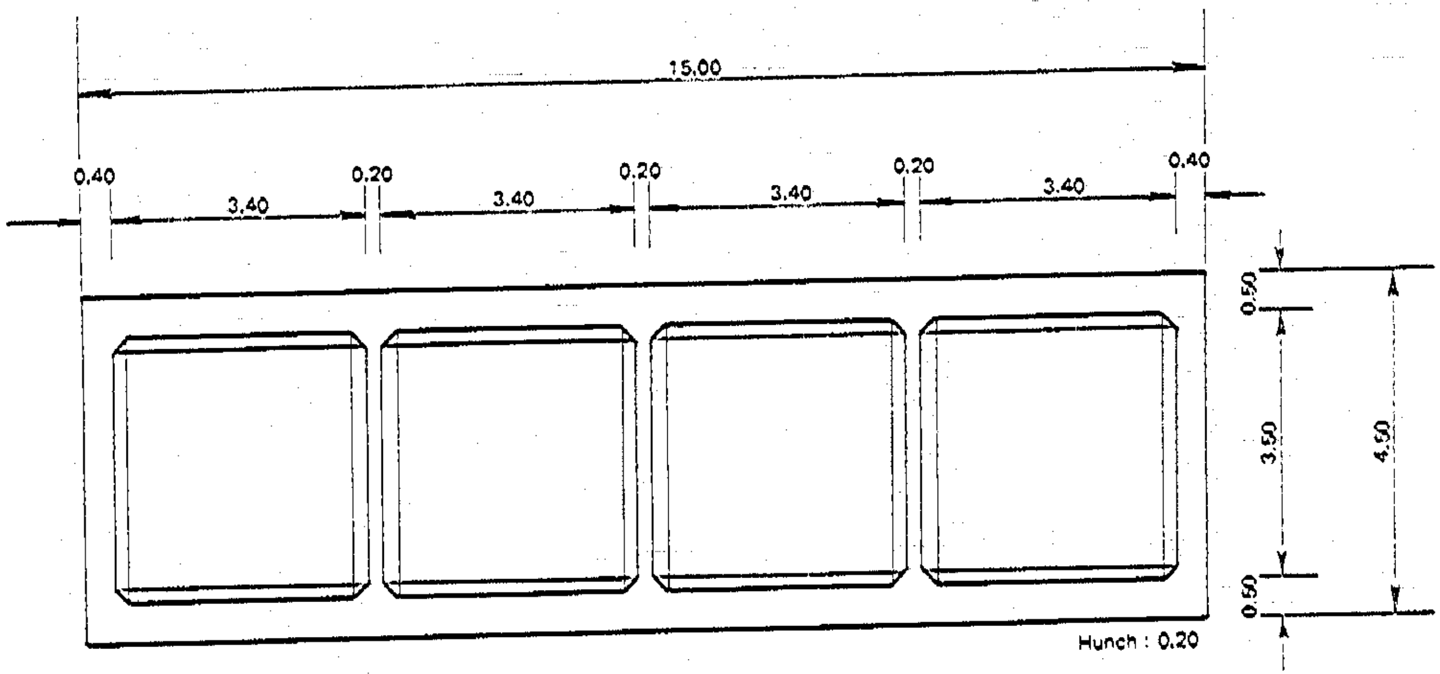


Fig. – V.3.19 Pavement for KQ Container Yard

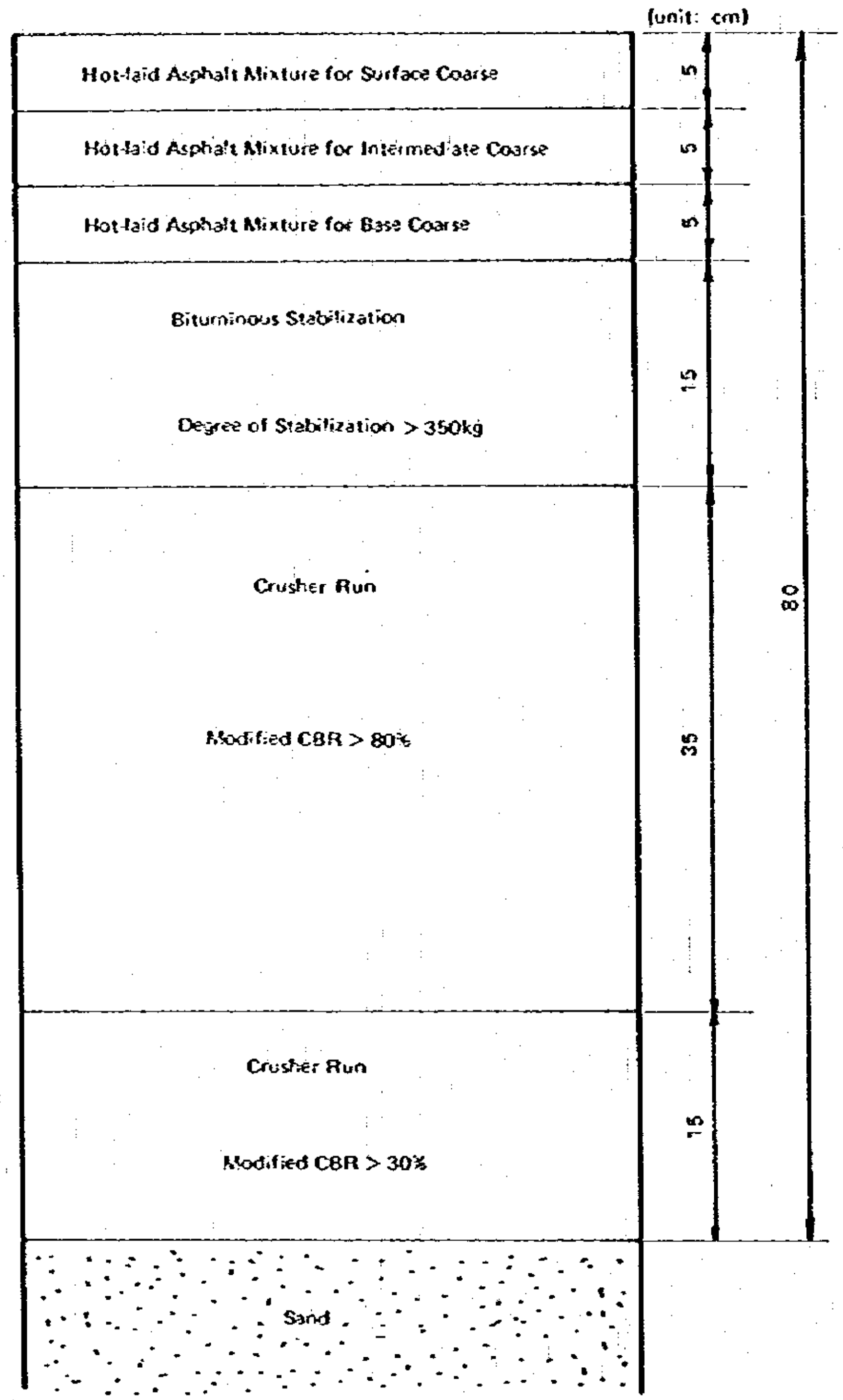
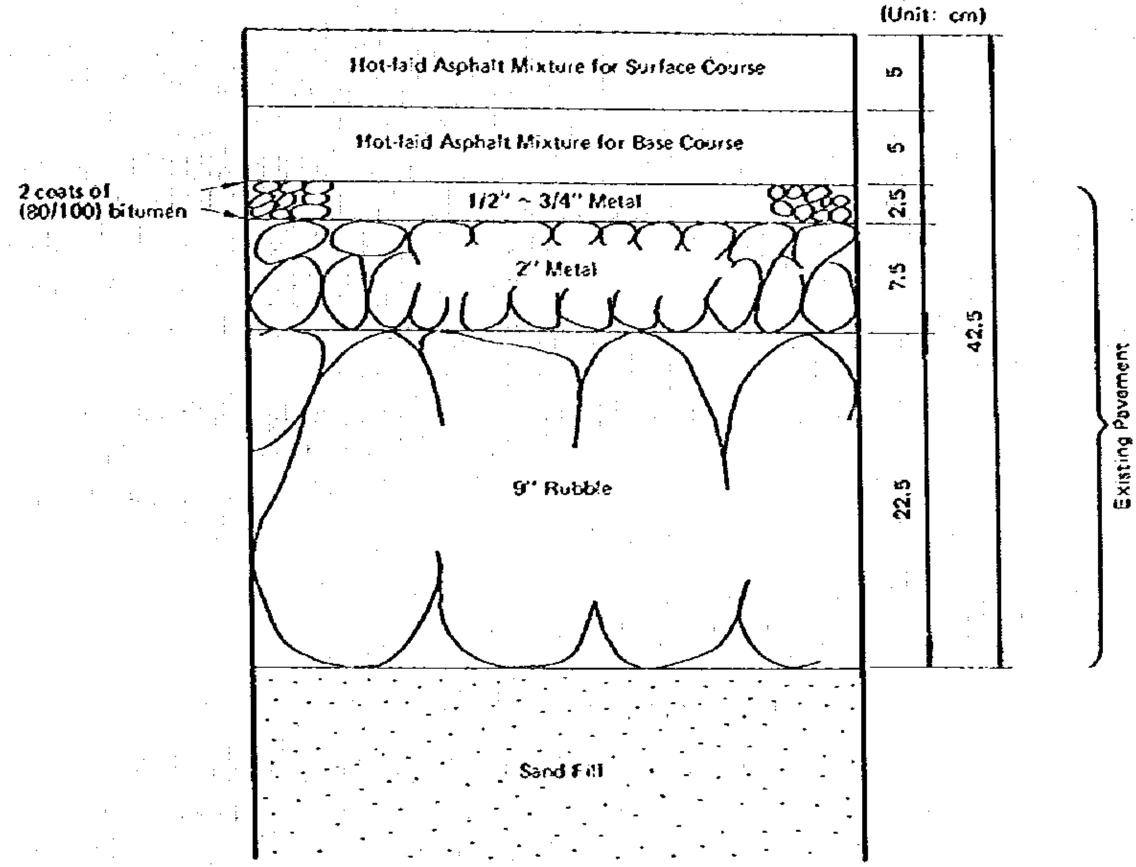


Fig. – V.3.20 Pavement for QEQ No. 5 Container Yard



CHAPTER 4 CONSTRUCTION PLAN

Civil engineering works included in the Urgent Plan consists of the containerization of a 200 meter section of the Queen Elizabeth Quay No.5, construction of the 550-meter Korteboam Terminal, comprising a 300-meter-long container berth and 250-meter-long conventional berth, and related works including dredging of the port basin (−12m) and improvement of the port road system.

Containerization work of the Queen Elizabeth Quay aims at completing a 200 meter section of quaywall for −12m, with the target year for opening set at 1982. The Korteboam terminal, with a total length of 550-meters and the alongside depth of −12m, will be constructed with the target year for service set at 1984. The container crane rail and its foundation works over 250-meter-long conventional berth will be executed in the Urgent Plan, in order to avoid any re-execution in future extension of the container berth in the Master Plan.

It is desirable to complete the port road improvement as early as possible to be ready for the containerization of the Queen Elizabeth Quay. As the road work will affect existing buildings, a 2 year period is allocated for the completion of the works, by 1983. The roadway will have two lanes. Locations of the works are shown in Fig.-V.4.1.

4-1 Basic Concept and Methods of Construction of Major Facilities

4-1-1 Containerization of the Queen Elizabeth Quay

The construction of the 200-meter-long quaywall of the Queen Elizabeth Quay No. 5 was completed as a national project of Sri Lanka. The proposed containerization works will consist of building a new foundation for container crane rails and of providing a container yard behind it. The work for crane rail foundation is comprised mainly of driving steel pipe piles and placing concrete beams, all of which will be performed on the shore. The container yard construction work is comprised mainly of performing an intensive paving work over the existing pavement foundation, to permit the passage of heavy vehicles.

4-1-2 Construction of the Korteboam Quay

As the Korteboam Quay will be constructed at a site where the bedrock appears at shallow depths, a caisson type quay is adopted.

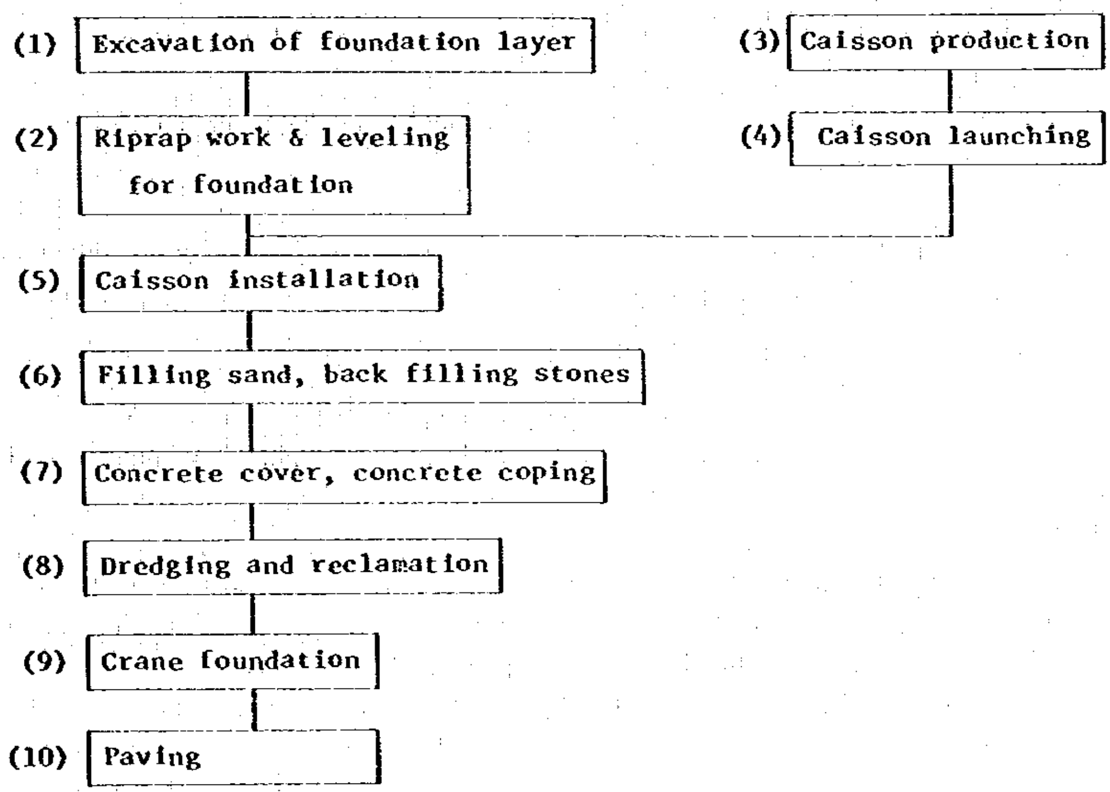
Sufficient seawater calmness is maintained for the work, since the Korteboan Quay is located in the Port of Colombo. However, full precautions will be necessary because of possible overlapping between construction work and ordinary cargo handling work in the Port. Particularly, it seems difficult to secure the space for a construction camp. A caisson yard is necessary for producing caissons, but shoreline for constructing such a yard is not available so that a floating dock will be used. As the caisson production must be done with high accuracy and efficiency, it is desirable to utilize a part of the quaywall or revetment for the floating dock to provide the fullest supports required. The idea of using the existing quaywall has to be discarded as port facilities are fully utilized at present.

The floating dock will in the beginning be anchored in front of the Coaling Jetties with depth to −8m, to manufacture caissons for the south revetment of the Korteboam Quay (about 300-meter-long). After the completion of the south revetment and the backfilling of stones there, the floating dock will be moored and fixed to it, to produce caissons for the north revetment and quaywall. Caissons used for the south revetment are of sizes that can be re-used for the execution of the Master Plan in the future.

Caissons shall be installed beginning with the south revetment, followed by the north revetment and the −12m-quaywall; the −12m-quaywall will be started from the north. Reclamation work shall be started from the north without waiting for the completion of the installation of all caissons for the −12m-quaywall. Upon completion of reclamation in the area behind the northern 300-meter section of the −12m-quaywall, the paving work will be started as soon as the subbase is stabilized.

Construction methods of major works are described in Fig.-V.4.2.

Fig. – V.4.2 Construction of Caisson Type Quaywall



(1) The seabottom foundation will be excavated by a grab dredger with capacity of about 2 m^3, and the spoil deposited to a reclamation area using dump barges.

(2) Rubblestone will be transported by dump trucks from Mahara and Hapugahakanda, located 13 miles to the northeast of Colombo, brought to the Coaling Jetties in the Port, and discharged by a self-propelled barge with grab. Leveling of rubblestone surface will be performed by divers. The surface on which the caisson is to be installed must be leveled with special care.

(3) The first 16 caissons will be manufactured on two (2,500 ton class) floating docks anchored at a water depth of −8.0m in front of the Coaling Jetties. Concrete forms and reinforcing bars will be transported by pontoons from the Coaling Jetties and concrete poured by floating concrete mixers. Caissons produced at the sea will be used for the south revetment. And the remaining 59 caissons will be produced on two froating docks, utilizing the south revetment. Materials for caissons can be directly transported by overland vehicles from the Coaling Jetties to the south revetment using the Access Road built on the rubblestone. The fresh concrete will be transported from the concrete plant by an agitating truck, then pumped and poured by concrete pump trucks. In addition, for the purpose of lowering occupancy rate for each caisson of the floading dock, and to increase construction speed, jointing on sea will also be adopted on the submerged rubble mount.

(4)(5) Upon completion of caissons, the water in the caisson will be drained to bring it afloat from the underwater mound, the caisson will be towed by tugboat to the location of installation, and sunk into position by filling with water.

(6) Sea sand for the caisson fill will be collected by a self-propelled barge with grab from the mouth of the Kerani River, and poured into the caisson immediately after its installation. Backfilling rubble will be placed in position by a self-propelled barge with grab, the stones previously stockpiled at the Coaling Jetties.

(7) Concrete for the cover and the coping will be transported and poured by agitating trucks. The concrete for the coping will be poured after the reclamation work is completed, and after confirmation of caisson settlement.

(8) The reclamation fill will be discharged directly to the site, as shown in Fig.-V.4.1, using a 4,000-HP pump dredger, floating discharge pipes and submarine pipes. A spillway will be provided near the corner of the south revetment and −12m-quaywall.

(9) Since the seaside crane rail is to be installed on the coping concrete of the caissons, special attention should be paid to the close relationship between the rail and coping concrete placement. For the landside crane foundation, steel pipe piles should be driven into the reclaimed ground and beam concrete be placed.

(10) Asphalt concrete will be used for pavement.

4-1-3 Construction of Port Road System

The road network of the Port should be built with 10 meter wide 2-lane roads, and connected with the inland truck road at the rear of the Colombo Dockyard Ltd.. However, it is important to exercise special care in the transfer and demolition of existing buildings in the Port. Two tunnels are to be built in connection with this road construction work. In addition to the points mentioned above, the widening of the road to 4-lanes in the future should be also taken into consideration in establishing the optimum routing.

Since the paving is to be performed on the existing subbase and many existing roads can also be utilized, a relatively light subbase course may be adopted.

4-1-4 Dredging of Port Basin

The present water depth of −10.0 m to −11.0 m in the basin will be increased to −12.0 m to match the completed new container terminal. The estimated total amount of dredged spoil is 1,500,000 m^3. This amount will be excavated by dredgers owned by the Colombo Port Commission in a three year period from 1981 to 1983. Only the quality spoil should be discharged to the reclamation area and the rest be disposed of outside the Port.

4-2 Worksite Camp

The worksite for the caisson type quaywall should be located with due consideration given to the caisson yard, concrete plant and storage of stone. Shown in Fig.-V.4.3 is the layout of the camp when the south revetment is used as the caisson yard. A considerable amount of stone (5 to 60,000 m^3) will be required for the access road, foundation and backfilling work in the early stage of the work. For this reason, a land space greater than 200 m x 150 m will have to be secured for the temporary storage of stones.

It is assumed that construction craft working outside the Port will take refuge in the port basin during rough weather.

Minor repair of construction crafts and equipment will be performed at facilities available in the Port.

Though the majority of caissons will be manufactured on the floating docks; a 1,200-ton ship Ⓐ shown in Fig.-V.4.3 can be utilized for speeding up the completion of the south revetment of the Korteboam Quay. The New Boat House shown in Fig.-V.4.3Ⓑ is an important existing facility that can be utilized for storing and fabricating of concrete forms and reinforcing bars.

4-3 Construction Materials, Equipment and Crafts

4-3-1 Construction Materials

The quantities of main construction materials are shown in Table-V.4.1. Though a sufficient amount of cement is expected to be produced in Sri Lanka (about 40,000 tons/month), procurement from abroad has been considered since large projects, including "Mahaweli" are presently on-going. Though approximately 400,000 tons of rubble stones are expected from the quarry in Mahara district owned by the Colombo Port Commission, a new quarry will have to be opened as the quantity mentioned above will be insufficient for the Project. There is a small quarry owned by a private firm in Hapugahakanda district. There are many prospective quarry sites which would be able to produce quality stones in this district, and the roads are well maintained because of the presence of an oil refinery. A quarry having a capacity of 400,000 tons should be developed in this district to supply stones for the Port of Colombo. However, equipment and trucks necessary for cutting out and transporting stones will have to be procured from abroad as a shortage of this equipment is expected because the quarry operation in Sri Lanka is small in scale. Special materials such as steel and rubber will also be procured from abroad. In addition, materials requiring high accuracy in construction such as forms and scaffolds needed for the caisson production will also be procured from abroad.

4-3-2 Construction Equipment and Clafts

A number of construction crafts are owned by the Colombo Port Commission for the maintenance and operation of port facilities and for the cargo handling operation. Principal particulars of crafts owned by the Port are shown in Table-V.4.2. As these crafts are fully mobilized for daily operations and cargo handling, it would seem very difficult to use them exclusively for the construction work of the Project. However, the towage and transportation of the crafts from abroad would necessitate considerable expenditure, resulting in an increase of the overall construction cost. Thus, floating equipment and special crafts that will be used continuously for a long period of time in construction works will be chartered and transported from Singapore, while crafts required temporarily, for several months, will be secured from the Port of Colombo.

Of the onshore machinery, trucks necessary for transporting stones are in short supply and the number available for the Project is limited, so that the majority of them will be procured from abroad. Special purpose vehicles and concrete plants will also be procured from abroad.

Major crafts and equipment to be used are shown in Table-V.4.3.

4-4 Construction Plan

4-4-1 Days of Operation

(1) Work outside the Port

The Port of Colombo faces the Indian Ocean; the works will be greatly affected by wind waves coming from the west. Taking the wave hights (1m, 50 cm) that will affect the construction crafts as parameters, the frequency of occurrence of such waves by month is shown in Table-V.4.4 (refer to I-2-2 "Natural Conditions").

The work to be performed outside the Port consists mainly of the collection of filling sand by self-propelled grab, barges and of reclamation fill by the pump dredger. The highest waves under which the work is possible is 50 cm and 1.0 m maximum, respectively. The former work being associated with the installation of caissons, will have to be done once per day over several days. As the sand is partially available from the Port, these shall be no problem outside the Port with the annual average calmness (50 cm max.) of 64%. As the latter work, collection of reclamation fill, must be done continuously outside the Port, the calmness will greatly affect the work. According to the construction schedule (Table-V.4.5), the reclamation work is to be conducted between December and July, during which June and July may have stomy weather. Though it is possible to collect certain amount of sand from part of the port basin after an investigation of bottom materials, not much can be expected as the rock stratum may appear at the depth of −15m. Thus, the work outside the Port will be performed mainly by a large pump dredger that is capable of working with wind waves.

Shown below are the average annual rate of operation of the dredger:

- Number of non-operational days due to wind waves:
  $a = 30 \text{ days} \times 0.18 \fallingdotseq 6 \text{ days/month}$
- Number of days necessary for periodic repairing:
  $b = 2 \text{ days/month}$
- Number of operational days:
  $30 \text{ days} - 2 \text{ days} - 6 \text{ days} = 22 \text{ days/month}$

(2) Work in Port and on Shore

As the work in Port and on shore will be performed in the Port area, they will not be affected by waves. Strong winds affecting the work will not blow continuously, and the rainfall will be about the same as the wind. Thus, the number of operational days will be 24 days/month, excluding 5 holidays and 1 day for repairs.

4-4-2 Construction Schedule

The construction schedule for the major facilities is shown in Table-V.4.5. The schedule shows that services shall begin in 1982 for the Queen Elizabeth Quay Container Terminal and in 1984 for the Korteboam Terminal. Because of the limited construction period, the paving work on the Korteboam Quay will be started from the north side of the container terminal before the completion of the reclamation work.

Table – V.4.1 Major Construction Materials

Material	Item	Unit	Quantity	Supply		Remark
				Foreign	Local	
Sand, Stone & Cement	Stone	m^3	260,000		O	Rubblestone, backfilling stone
	Filling sand	m^3	90,000		O	Caisson filling
	Reclamation fill	m^3	1,800,000		O	
	Cement	t	12,000	O		Caisson, Crane beam
	Fine aggregate	t	27,000		O	Same as above
	Coarse aggregate	t	39,000		O	
Steel	Steel pipe pile	No.	260	O		ϕ711.2, t12,
	Rail	m	1,400	O		(ℓ = 17~24 m)
	Reinforcing bars	t	2,900	O		75 kg/m
Others	Steel forms			O		
	Scaffolds			O		
	Fuel				O	
	Sand protection mat			O		
	Rubber fender			O		

Table -- V.4.2 (a) Dredgers Owned by CPC

	Kimbula	Bin Ura	Boowalla	Kakuluwa	Diyakawa
Year Built	1967	1971	1975	1962	1972
Builder	Alexander Stephen & Co., U.K.	Fleming & Ferguson U.K. Assembled by Port Comm.	Dixie Dredger Corporation	George Brown & Co., U.K.	IHI Co., Japan
Type	Cutter Suction Dredger	Hydraulic Drive & Winches	Cutter Suction Dredger	Self Propelled Grab Type	Drag Suction Dredger
Pontoon Size	30' x 20' x 55'	L--151' B--30' D--10'6"	40' x 20' x 10'	L--142' B--29' D--12'	L--65m B--11.8m D--5.0m
Capacity		315 cu.yds./h	180 cu.yds./h	100 cu.yds./h	5,000 m³/h (water)
Maximum Depth	35'	45'	30'	75'	62'
Pump Type	Felmming & Ferguson	Buckets -- 17½ cu.ft. each			
Duct	12" 12"		16" 14"		
Engines	2/Cat -- 343 & 333	Cat -- 343 333	Cat D 346 D 334	Twin Crossby ERL4 400HP	Twin Yanmar 6MA-HTS 900HP
Cutter Drive	Hydraulic		Electric Motor		
Dead Weight		300 Tons		Load 705 t, Empty 470 t	Load 2,255 t, Emply 935 t
Pump Drive	Hydraulic	Hydraulic	Electric		
Capacity (Hopper)				275 cu.yds	850 cu.yds
Speed				8.5 K	9.0 K
Grab Capacity				2.5 cu.yds	
Condition	out of commission	Working	Working	Working	Working

Source: CPC

Table – V.4.2 (b) Ships Owned by P(C)C

Type	Total	In Commission	Under repairs
Lighters	298	142	156
Tugs	15	8	7
Launches	27	9	18
Passenger Clafts	8	5	3

Table – V.4.2 (c) Tugboats Owned by CPC

Towing Tugs	Condition
(1) Kanchadeva 1961 – Engines Widdop 275 HP	Hull needs repairs
(2) Pussadeva 1961 – Widdop 275HP	Not in good condition
(3) Velusumana 1965 – Crossby 260HP ERN 8	Engine needs repairs
(4) Madnwa 1965 – Lister Blackbore – 280HP	Good condition
(5) Theraputtabaya – 1968 – Crossby 375HP – HRN8	Hull needs repairs Generally good

Table – V.4.2 (d) Onshore Construction Machinery Owned by CPC

Type	Lifting Capacity	Quantity
Truck Cranes	30 t	1
	12 t	3
	10 t	1
	7 t	2
	6 t	3
Crawler Cranes	30 t	1
	20 t	1
	13 t	1

Table – V.4.3 List of Crafts and Equipment to be used

Equipment	Capacity	Quantity	Availability in Sri Lanka
Grab dredger	$2m^3$/grab	1	yes
Barge	$300\ m^3$	1	yes
Tugboats	250 ps and under	4	yes
	250 ps and above	3	no
Self-propelled barge with grab	$350\ m^3$ in capacity	4	no
Floating docks	2,500 t	2	no
Divers' boats		10	no
Pump dredger	4,000 ps	1	no
Anchor barge		2	no
Floating concrete mixer		1	no
Tractor shovels	$2.3\ m^3$	7	no
Dump trucks	10.5 t	50	no
Concrete mix trucks	3.2 t	4	no
Concrete pump trucks	160 ps	2	no
Truck cranes	Capacity 7 to 20 tons	5	yes
Pile driver	D 22	1	no
Concrete plant	$70\ m^3/h$	1	no

Table – V.4.4. Frequency of Occurrence of Wave Heights by Month

(Unit: %)

Wave height \ Month	1	2	3	4	5	6	7	8	9	10	11	12	Total
0.49m and under	69	73	78	79	72	49	43	41	48	58	78	79	767 (64)
0.50m to 0.99m	18	18	19	14	10	13	25	26	22	19	13	17	214 (18)
1.00m and above	13	9	3	7	18	38	32	33	30	23	9	4	219 (18)
Total	100	100	100	100	100	100	100	100	100	100	100	100	1,200 (100)

Table – V.4.5 Construction Schedule for Urgent Plan

No.		Item	Unit	Quantity
1	QEQ	Crane foundation	m	200
2	QEQ	Paving	m^2	40,000
3	QEQ	Offices & Others	m^2	1,135
4	KQ	Access road	m	150
5	KQ	South revetment	m (caisson)	310 (16)
6	KQ	North revetment	m (caisson)	350 (20)
7	KQ	Quaywall	m (caisson)	550 (39)
8	KQ	Reclamation	m^3	1,830,000
9	KQ	Yard paving	m^2	165,000
10	KQ	C.F.S	m^2	6,000
11	KQ	Electric & Others	Set	1
12	KQ	Offices & Others	m^2	3,450
13	Road		m	5,700
14	Dredging		m^3	1,500,000
15	Survey		Set	1
16	Design		Set	1
17	Construction Supervision		Set	1

Note: Shown in ( ) is caisson production

Fig. – V.4.1 Locations of Civil Engineering Works – Urgent Plan

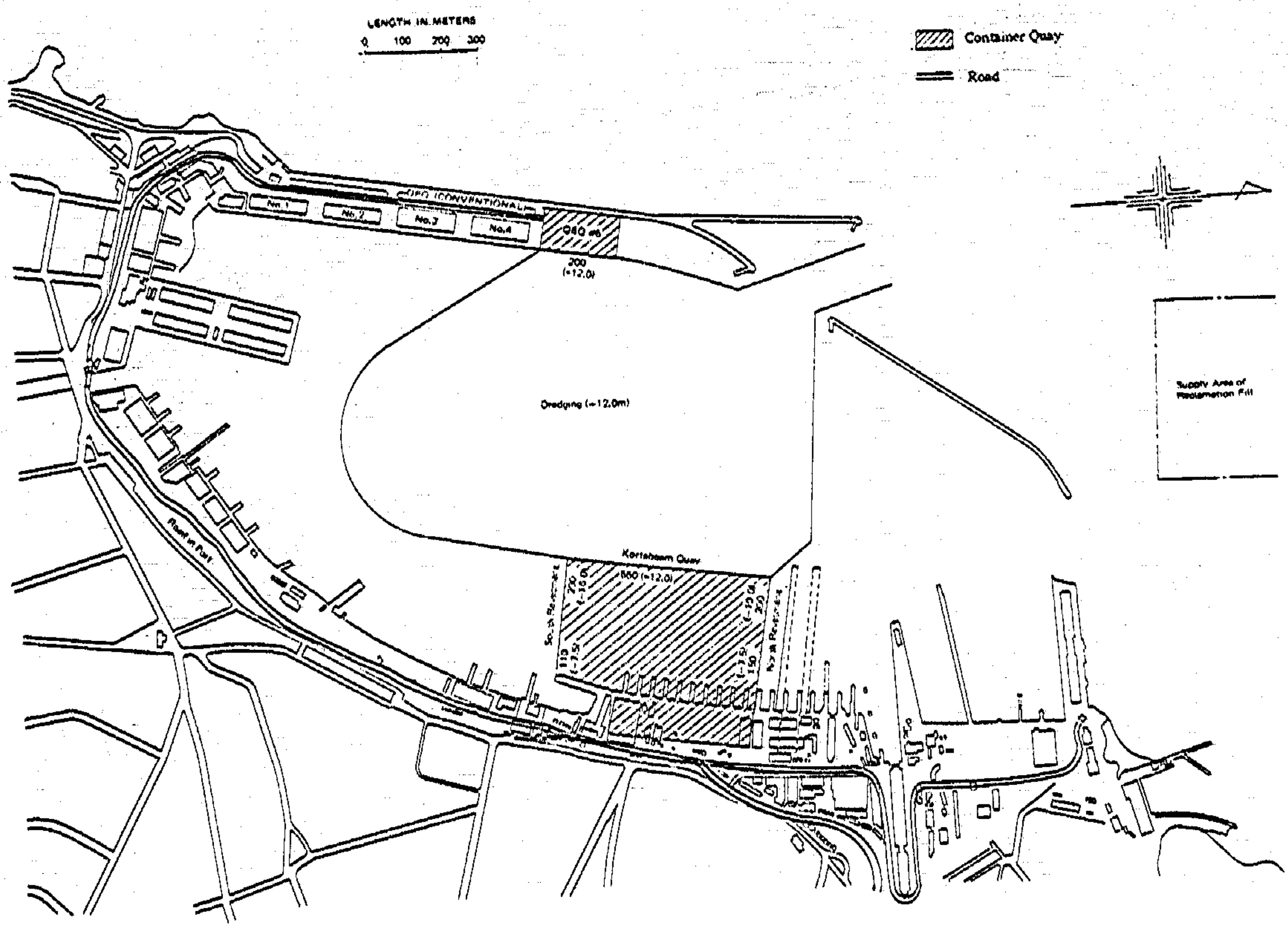
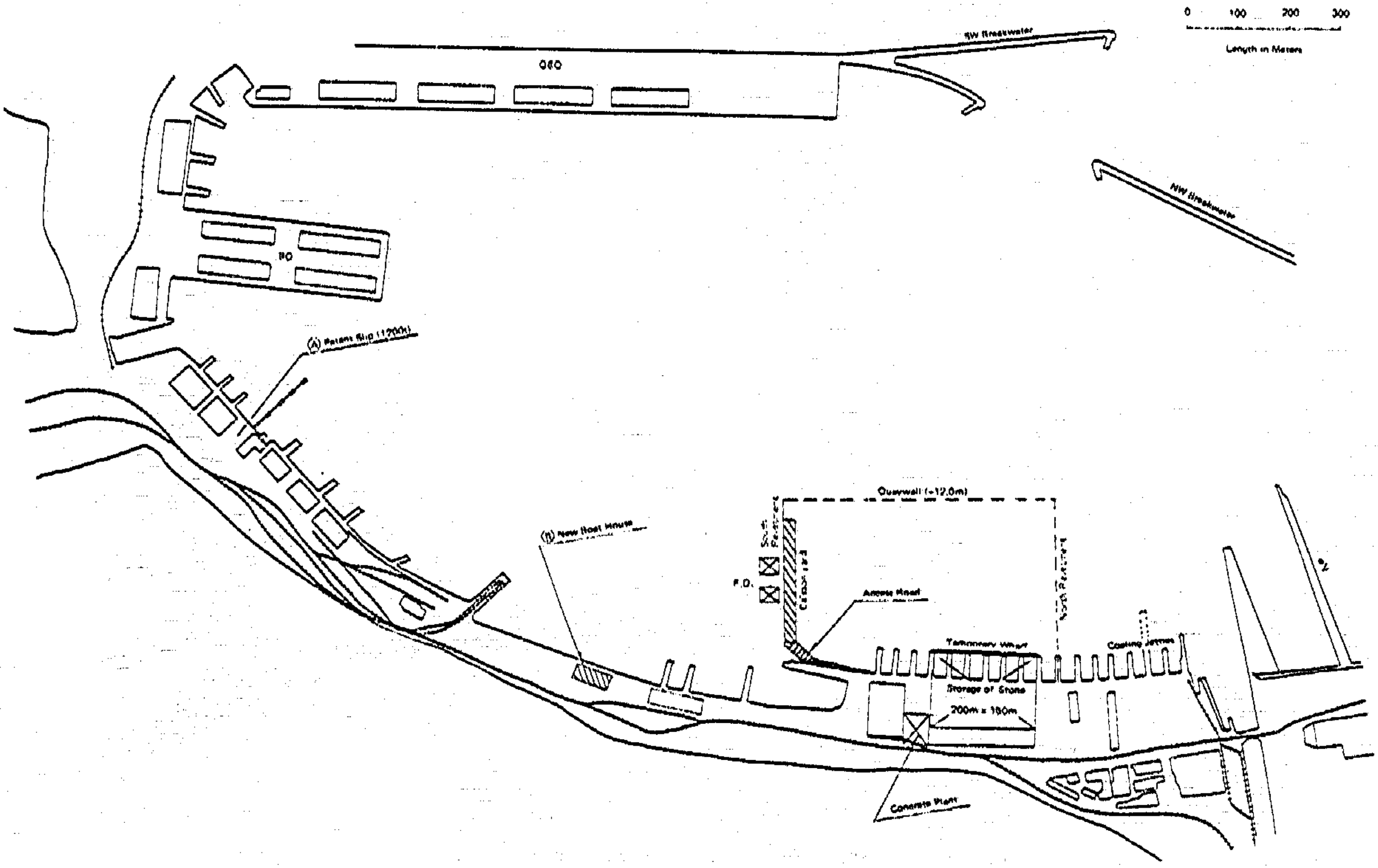


Fig. – V.4.3 Construction Worksite Camp



CHAPTER 5 ESTIMATE OF CONSTRUCTION COST

The construction cost of the major facilities was estimated based on the unit price method and in accordance with the "Construction Plan" given in the preceding chapter. Basic prices of construction materials were determined as shown in Table-V.5.1, based on the results of field investigation. However, the following prerequisites were used in estimating construction costs:

a) Prices as of June, 1979 are used for both local and foreign currency portions, and the rise in commodity prices is not taken into account. The exchange rate as of June 1979 was determined as follows using IMF data:

US$1 = Rs. 15.625 = ¥218.89 (Rs.1 = ¥14)

b) Crafts unavailable in Sri Lanka will be procured from Singapore and its vicinity, and taken to the port. Equipment and construction materials domestically unavailable will be transported from Japan. The hire or rental of crafts and equipment are determined based on Japanese standards.

c) All materials and equipment to be imported from Japan are expressed in CIF prices without improt duties.

d) Costs of compensation for fisheries and lands, and of moving houses or buildings which may accompany this Project are not included.

e) 15% of the overall construction cost is considered as physical contingency.

The project costs of the Urgent Plane is shown in Table-V.5.2. The total investment amounts to US$70.458 million, of which US$54.040 million, or 77%, is the foreign currency portion.

Foreign currency is needed for the following items:

a) Specially fabricated products such as fenders and steel, and scaffolds and forms necessary for insuring the accuracy of construction and adhering to the time schedule.

b) Transportation, rental and purchasing costs of construction equipment and crafts which are to be procured from abroad.

c) Costs of mobilizing skilled labours, such as crewmen of special crafts.

Shown in Table-V.5.3 is the annual funding plan for 1980 to 1983 prepared in accordance with Table-V.4.5 "Construction Schedule".

Refer to V-2 "Facility and Equipment Plan" for the details of cargo handling equipment shown in Table-V.5.3.

Table – V.5.1 (a) Basic Price

(Unit: US$)

Item	Specification	Unit	Basic Price		
			Foreign	Local	Total
Rubblestone	50 ~ 500 kg/each	m^3	13.9	2.3	16.2
Leveling of rubble base	underwater	m^2	14.0	1.5	15.5
Rubblestone	1,000 ~ 2,000 kg/each	m^3	16.5	2.5	19.0
Leveling of rubblestone surface	Underwater	m^2	7.9	0.9	8.8
Concrete	σ = 240 kg/cm^2	m^3	68.0	14.2	82.2
Rainforcing bars	Including fabrication	t	406.6	32.0	438.6
Filling sand	Sea sand	m^3	5.1	0.1	5.2
Dredging	In Port	m^3	0.0	1.9	1.9
Dredging	Outside port	m^3	2.3	0.2	2.5

Table – V.5.1 (b) Rough Estimate of Construction Costs for Main Structures

Facilities	Unit	Unit Construction Cost (US$)	Remarks
–12.0m Caisson quay wall	m	20,750	Including crane foundation
–10.0m Caisson quay wall	m	14,200 (16,470)	Shown in ( ) is the unit cost of placing concrete at sea
–7.5m Caisson quay wall	m	9,960 (12,230)	
CFS	m^2	218	Structural steel and slate
Paving of road and apron	m^2	16	Asphalt concrete
Paving of container yard	m^2	31	Asphalt concrete

Table – V.5.2. Project Cost of Urgent Plan

(Unit: Thousand US$)

Item		Unit	Quantity	Cost (%)
Conventional Berth	Cargo Handling Equipment	Set	1	7,537 (10.7)
	Sub Total			7,537 (10.7)
Container Berth	QEQ #5	Berth	1	2,293 (3.2)
	KQ #1 (Quaywall, CFS)	Set	1	33,912 (48.1)
	Dredging	M.m^3	1.5	2,880 (4.1)
	Container Equipment	Set	1	13,794 (19.6)
	Sub Total			52,879 (75.0)
Road		km	5.7	1,524 (2.2)
Engineering		Set	1	2,111 (3.0)
Physical Contingency		Set	1	6,407 (9.1)
Grand Total				70,458 (100.0)

Table – V.5.3 Yearly Investment Plan

(Unit: Thousand US$)

Construction year			Quantity	1980			1981			1982			1983			Total		
				Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
Civil engineering facilities	QEQ	Crane foundation	200 m				1,248	60	1,308							1,248	60	1,308
		Heavy paving	40,000 m²					320	320								320	320
		Offices & Others	1,135 m²				226	146	372							226	146	372
		Power, lighting and water supply	1 Set				251	42	293							251	42	293
		Sub total					1,725	568	2,293							1,725	568	2,293
	KQ	Access road	150 m				378	62	440							378	62	440
		South revetment	310 m				4,055	521	4,576	51	39	90				4,106	560	4,666
		North revetment	350 m				1,856	251	2,107	1,190	168	1,358				3,046	419	3,465
		Quaywall	550 m							7,913	1,004	8,917	2,118	340	2,458	10,031	1,344	11,375
		Reclamation	1,830,000 m³							525	50	575	3,672	351	4,023	4,197	401	4,598
		Paving of yard	165,000 m²											5,050	5,050		5,050	5,050
		C.F.S.	6,000 m²										792	516	1,308	792	516	1,308
		Offices and Others	3,450 m²										589	382	971	589	382	971
		Power, lighting and water supply	1 Set										1,913	126	2,039	1,913	126	2,039
		Sub total					6,289	834	7,123	9,679	1,261	10,940	9,084	6,765	15,849	25,052	8,860	33,912
	Dreding		1,500,000 m³					960	960		960	960		960	960		2,880	2,880
	Roads		5,700 m					762	762		762	762					1,524	1,524
	Sub total (1)						8,014	3,124	11,138	9,679	2,983	12,662	9,084	7,725	16,809	26,777	13,832	40,609
Equipment	Q. E. Q (Container)		1 Set				4,461		4,461							4,461		4,461
	K. Q (Container)		1 Set										9,333		9,333	9,333		9,333
	Conventional berth		1 Set	7,537		7,537										7,537		7,537
	Sub total (2)			7,537		7,537	4,461		4,461				9,333		9,333	21,331		21,331
Engineering	Survey and design		1 Set	594	169	763	238	69	307							832	238	1,070
	Construction supervision		1 Set				278	69	347	278	69	347	278	69	347	834	207	1,041
	Sub total (3)			594	169	763	516	138	654	278	69	347	278	69	347	1,666	445	2,111
Physical contingency [15% of (1) + (3)]				89	25	114	1,280	489	1,769	1,493	458	1,951	1,404	1,169	2,573	4,266	2,141	6,407
Total				8,220	194	8,414	14,271	3,751	18,022	11,450	3,510	14,960	20,099	8,963	29,062	54,040	16,418	70,458

CHAPTER 6 ECONOMIC ANALYSIS

6-1 Method and Alternative

6-1-1 Method

The value of costs and benefits in the economic analysis is evaluated in two ways, that is, by shadow pricing and by market pricing. It should be noted that sufficient statistics are not always available, and statistics themselves do not necessarily give correct informations due to the recent drastic changes in the economic policy of the country, while the shadow pricing inevitably requires statistics. These are the reasons why the analysis based on the market pricing, in addition to the shadow pricing, is employed here.

6-1-2 Alternative

As an alternative to be considered for the sake of comparison, the case without investment, called the WITHOUT case, is employed.

As already stated, the maximum dry cargo handling capacity of the existing alongside berths, without heavy port congestion, appears to be about 2,200 thousand freight tons. This maximum capacity is increased by about 1,500 thousand freight tons to about 3,700 thousand freight tons after the completion of the Urgent Plan.

In the WITHOUT case, 500 thousand freight tons out of the increased 1,500 thousand freight tons is assumed to be handled at the existing alongside berths allowing port congestion to the maximum degree and the remainder of 1,000 thousand freight tons be handled at the midstream berths. Foods is considered not to be handled at the midstream berths. Assuming that an average 1,700 freight tons is brought/loaded per vessel, the number of vessels to clear 1,000 thousand freight tons of cargo assigned to the midstream berths is calculated as about 590. By assuming again that the number of days necessary for cargo handling is inversely proportional to the cargo handling productivity, about 10 days are required for cargo handling by lighters against about 5 days for cargo handling at the alongside berths. Then, about 16 midstream berths are concluded to be necessary to clear their assignment. This is the number that can be met with the existing midstream berths. Concerning the total number of lighters required, assuming that tonnage loaded per lighter be 50 tons and the cycle time of lighter be one day, 20,000 lighter cycles per year or 55 lighters per day is the necessary numbers. These are also the numbers that can be met with the existing lighters (out of 298 lighters, 142 are in commission).

Thus, in the WITHOUT case, no additional investment is considered for facilities and lighters.

6-1-3 Deflators

All the benefits and costs to be evaluated are expressed in terms of 1979 prices. Deflators to convert them into the 1979 prices are discussed here. Changes in minimum wages, per capita GNP and the Colombo consumers' price index from 1972 to 1978 are shown in Table – V.6.1.

As a deflator for wages, the value in the non-agriculture sector is employed in the analysis, since it is considered to be the figure most closely related to various personnel expenses. Shadow wage rate, however, is converted by a deflator obtained from the agriculture sector.

In the case of materials, fuel, equipment, etc., the rates of rise of individual prices, if available, are employed as deflectors. Otherwise, the Colombo consumers' price index is employed.

The arithemetic mean of the index of the non-agriculture sector and the Colombo consumers' price index is employed as a deflator to convert what is composed of labour and goods and what can not be, in advance, determined its composition such as repair cost.

For the price conversion from 1978 to 1979, 15%, the rate of rise of the implicit price index (ΔGNP at current market prices/ΔGNP at 1959 constant prices) which is given in 1980 Budget Speech is used for labour and 12.1%, the rate of rise of the Colombo consumers' price index, which is also given in the same Speech is employed for goods.

6-2 Benefits

6-2-1 Benefit Items

(1) Formulation of Benefits Items

After the present government took office in 1977, the government has energetically promoted the economic development through the liberalization of the imports the implementation of the accelerated Mahaweli Development Scheme, the establishment of the Free Trade Zone, etc.

Under such circumstances, it is considered indispensable for the economic development being sought by this country to increase the cargo handling capacity of the Port and, at the same time, to meet the demand for containerization of the Port. For the benefits which are brought about by the development and the improvement of the Port, those described above are the biggest. However, those kind of benefits are not exclusively attributable to the port investment, further, its quantification is very difficult.

It was already pointed out that the location of the Port of Colombo is advantageous as a center of entrepot trade.

To promote, by the investment for the Plan, this kind of function of the Port leads to the improvement of not only nation's economic situation but also nation's international status. The benefits that are expected in various fields cannot easily be evaluated and they are themselves immeasurable.

Thus, the following three benefits are evaluated and considered in the analysis.

a) Reduction in cargo handling cost – Reduction in cargo handling cost by raising cargo handling productivity through mechanization and containerization.

b) Reduction in ships' staying cost – Reduction in ship cost for awaiting berth and for loading/unloading cargo mainly through the rise of cargo handling capacity and productivity of the Port.

c) Value added earned by ship repair – Increase in the value added earned by the Colombo Dockyard Ltd. through the modification of a cargo handling berth in the North Guide Pier to a ship repair berth.

In addition to these measurable benefits, the following intangible benefits can also be counted together with those stated previously:

a) Contribution to the nation's economic development – Strengthening the basis for the nation's economic development through modernization of the Port

b) Entrepot trade center – Providing the function as a center for an entrepot trade handling tranship cargo and providing container feeder services to the neighbouring countries.

c) Reduction in damage to cargo – Reduction in damage to cargo through containerization and mechanization.

d) Reduction in transport period – Reduction in transport period through upgrading the port services.

e) Safety – Improvement of the safety in navigation through extending the waterway and expanding the turning basin.

(2) Attribution of Reduction Benefit in Ships' Staying Cost

Among the above three benefits, the whole benefit due to the reduction in ships' staying cost will not necessarily be attributed to Sri Lanka. This benefits will be primarily attributed to the operators of ships. A percentage of the benefit attributable, irrespective of directly or indirectly, to Sri Lanka (hereinafter referred to as a "feedback ratio") is discussed below.

1) Share of the Ceylon Shipping Corporation in Cargo Traffic

The merchant fleet in Sri Lanka is solely operated by the Ceylon Shipping Corporation (CSC) the body corporate supported by the government. The shafe of CSC in cargo traffic itself is assumed here as the ratio of the direct benefit to Sri Lanka.

Table-V.6.2 shows that the share of CSC in 1977 to 1978 is about 13% to 14%. Since the internal rates of return are calculated over 25 years from 1980 to 2004, the most likely feedback ratio for next 25 years must be chosen.

In this respect, the following two items are considered to affect directly to this feedback ratio.

a) Prospect of CSC fleet
b) Cargo traffic forecast

As for the item a), the feasibility study on the ship replacement for the next 5 years was carried out in 1979 and building three ships to replace old ships owned by CSC was recommended. This project is now under implementation. Thus, the increase in the share due to newer and better performance of the fleet is, to some extent, expected.

As for the item b), the cargo traffic forecast already given in the Part III shows the increase in dry cargo by 55% in 1988.

From the above discussion, a feedback ratio of 10%, which is the rounded figure of the expected share of CSC in cargo traffic, is employed as a case to be analysed.

2) Feedback Ratio in the Next 25 Years

Besides the benefit due to the reduction in ships' awaiting cost through the CSC's share in cargo traffic, the following factors appear not to be overlooked in consideration of the calculation period of 25 years, though they are much more ambiguous than the achieved share of CSC:

a) Long-term Prospect of the CSC's Share

According to the Code of Conduct for Liner Conference adopted at UNCTAD in 1974, 40% is mentioned as a trading country's share. Being supported by this, it is likely that the CSC's share will increase in the next 25 years. Among the sea routes through the Port of Colombo, there are some routes as shown in Table-V.6.2, where CSC's share has exceeded 40% already.

b) Raise in Port Tariff

A raise in the port tariff, excluding the container tariff which was revised in 1979, is being examined by the Sri Lanka Ports Authority. If all or a part of a raise in the port tariff corresponds to the reduction in the ships' staying cost, it can be said that all or a part of this benefit originally attributed to foreign ship operators is internilized by means of a raise in the port tariff.

It is suggested in the next chapter that an average 25% raise in the port tariff exclusive of the container tariff be necessary to secure the sound finance of the Sri Lanka Ports Authority. This 25% raise corresponds in monetary terms to a little less than 20% of all the benefit due to the reduction in ships' staying costs.

In this connection, a raise in a port tariff generally leads to a rise in local prices through a rise of import prices and to a drop in the competitive position in the world market through a rise of export prices. The above mentioned raise, however, does not involve these negative effects, since the raise itself is confined to the extent of the benefit.

c) Feedback through Economic Activities

It would be considered that the benefit attributed directly to foreign ship operators returns to Sri Lanka to some extent with some time lag through the market mechanism in the world shipping, though the structure of the world shipping is very complex.

With these situations in mind, a feedback ratio of 50% is employed in the present analysis besides that of 1 0%. This case would serve for a sensitivity analysis, as well.

6-2-2 Reduction in Cargo Handling Cost

It is considered that there is no appreciable difference in the administrative cost between the case of the Urgent Plan (WITH case) and the WITHOUT case, hence only the direct cost required for cargo handling will be evaluated here. The direct cost or the cargo handling cost consists of the following costs:

a) Labour costs, and

b. Operation/maintenance costs (repair cost, fuel cost, and light and water costs, etc.)

The costs required for operation and maintenance of quaywalls, transit sheds, CFS, power facilities, etc. excluding cargo handling equipment are separately estimated and, thus, are not included here. And, as a matter of fact, the depreciation is not included in the analysis.

The Port handled dry cargo of 2,637 thousand freight tons at alongside berths and of 308 thousand freight tons at midstream berths in 1978. The cargo handling cost in 1978 are shown in the 1st row of Table-V.6.3. The number of unskilled labours in cargo handling is estimated as about 80% of overall labours. The ratio in wages between skilled labours and unskilled labours varies widely from 1:1.4 to 1:6.7, and the average ratio of 1:4 in wages is employed here. The 2nd row in the same table shows these costs per ton of cargo handled.

Before estimating cargo handling costs both for alongside berths and for midstream berths in 1978, the costs of operating lighters is first calculated as follows based on the figures that the overall number of lighters is 298 and that of labours is 798:

Total :	603	thousand	US$
Labour costs:	467	"	"
Operation maintenance cost:	136	"	"

It is considered that the cargo handling by lighters is not too much different from the cargo handling at alongside berths in respect of gangs in ship and gangs at landing point.

Thus, the remainder, obtained after deducting lighter's operating cost shown above from the overall direct costs shown in the 1st row in Table-V.6.3, is allotted to the both types of cargo handling by considering that each cost might be inversely proportional to (gang hour productivity) X (number of gangs). Results are shown in the 2nd and the 3rd rows of Table-V.6.3

Next, cargo handling cost, after the operation of the conventional cargo handling equipment commerces in 1981, is evaluated by considering that the labour costs might be inversely proportional to (gang hour productivity) x (number of gangs) x (rate of berth occupancy). By referring to Part IV, calculations is done by using the figures on cargo handling productivity shown in Table-V.6.4. The ratio between unskilled labours and skilled labours is estimated to be almost the same as that used in the WITHOUT case.

Concerning the operation/maintenance cost, the cost required for newly introduced equipment is added to those previously required. The overall results are shown in the first row in Table-V.6.5.

Concerning the container terminal, the labour costs for the operation of a container terminal are generally governed by the way of operation, the ratio between FCL and LCL, etc. Here, the number of labours required for handling containers per berth is estimated about 1.5 to 2.0 times larger than that for the conventional cargo handling, and 1.5 times is employed for the

Queen Elizabeth Quay, while 2.0 times for the Korteboam Quay. The ratio between the skilled labours and the unskilled labors is estimated about 1:1.

The results are shown in the second and the third row in Table-V.6.5 for the Queen Elizabeth Quay and for the Korteboam Quay respectively.

The above results, excluding the operation/maintenance cost for newly introduced cargo handling equipment, are converted to 1979 prices and shown in Table-V.6.6.

The allotted yearly tonnages of cargo by facility both for the WITHOUT case and the WITH case are shown in Table-V.6.7. First, the yearly tonnage for the years other than 1983 and 1988 are estimated by a method similar to that used in Part III, then only the portion of tonnages that can be handled within the scope of the Urgent Plan is calculated and is shown in this table.

The value of reduction in cargo handling cost for each year calculated from this table is shown in Table-V.6.8.

6-2-3 Reduction in Ships' Staying Cost

In the WITHOUT case, the port congestion will be aggravated compared to that in 1978. This aggravation is caused mainly by an increase in both the awaiting period and the cargo handling period. According to the queuing theory, however, the congestion in 1978 is likely to reach a saturated state and the awaiting period become infinite theoretically. Thus, it is considered here that the awaiting period under the saturated state increases in proportion to the average cargo handling period which is evaluated here.

The average awaiting period and the average cargo handling period in the WITHOUT case for each year after 1980 are shown in Table V.6.9.

These periods in the WITH case in 1980 is exactly the same as those in the WITHOUT case. After 1981, the number of days of cargo handling per vessel in the WITH case decreases due to the mechanization in conventional cargo handling. Further, the container berth in the Queen Elizabeth Quay commences its operation after 1982, but the awaiting period is considered to be 1.7 days that is exactly the same as those in 1978, since the rate of berth occupancy for conventional berths slightly exceeds 100%. With the completion of the new container terminal in the Korteboam Quay by the end of 1983 and the commencement of its operation from 1984, the rate of beth occupancy for conventional berths decreases to less than 100%. Thus, the finite average awaiting period is estimated by the queuing theory. The average awaiting period for container vessels is separately estimated by the queuing theory. In applying the queuing theory, M/M/S was adopted to avoid overestimation of the benefits. That is, it is assumed that both the distribution of ships' arrival and the distribution of cargo handling period are random distributions. The results for the WITH case are shown in Table-V.6.9.

The total vessel-days staying in the Port is calculated by using Table-V.6.9 and the number of cargo vessels calling. This is shown in Table-V.6.10. The difference between the WITH case and the WITHOUT case is shown in the rightmost column in this table.

There are two methods for evaluating the ships' sta ying cost; one is to sum up the every expense required for ship's staying; and the other is to evaluate using time characterage. However, since the purpose of evaluation here is to evaluate the benefit not for an operators of a vessel but for Sri Lanka, it is more appropriate to adopt the time charterage which, as a matter of fact, is expressed in terms of "international market price". In addition, this serves for avoiding overestimation of the benefit, since the value evaluated from the time charterage is less than that from the summing up of every expense during ship's stay.

The time charterages of dry cargo vessels (1 year) in 1973 to 1974 and 1977 to 1978 (up to the second week in October) are shown in Table-V.6.11. The average time charterage is shown graphically in Fig.-V.6.1. The overall average tonnage of vessels calling the Port is about 12,200 DWT, while the average tonnage of them exclusive of oil tankers is about 8,000 DWT. The latter includes vessels calling exclusive for bunker and the average tonnage of cargo vessels only is not available. Thus, 10,000 DWT, a little higher than the latter, is employed as the average tonnage of cargo vessels calling the Port to avoid the overestimation.

The extraporation by a hypabola gives about 10.6 US$/DWT Month as shown in Fig.-V.6.1. Taking into consideration the time fluctuation of the charterage itself and the error possibly involved in the extraporation, about 70% of this or 7.5 US$/DWT·Month is finally employed here.

Both 10% and 50% of the lump sum of the reduction in ships' staying cost are shown in Table-V.6.12.

6-2-4 Value Added Earned by Ship Repair

The expected increase in the turnover of the Colombo Dockyard Ltd. through the modification of a cargo handling berth to a ship repair berth is, in 1979 prices, as follows:

Increase in number of dock-in ships:	12,	Turnover:	300 thousand US$
Use of the transferred ship repair berth:	60,	Turnover:	1,200 thousand US$
Total turnover			1,500 thousand US$

The breakdowns of the turnover of the Colombo Dockyard Ltd. in 1978 are shown in Table-V.6.13.

The value added is estimated as 777 thousand US$/year by multiplying the increase in the turnover shown above by the share of the value added given in this Table.

6-3 Costs

6-3-1 Construction Cost

The construction cost is shown in Table-V.6.14.

6-3-2 Cost of Purchasing the Cargo Handling Equipment

The cost of purchasing the cargo handling equipment is shown in Table-V.6.5.

6-3-3 Administration Cost

It is considered that there is no difference in the administration cost between the WITH and the WITHOUT cases.

6-3-4 Operation/Maintenance Cost

As shown in the next chapter, a fixed percentage of the construction cost or the cost of purchasing the equipment is adopted as the operation/maintenance cost. However, since the operation/maintenance cost for the cargo handling equipment is already taken into consideration when calculating the reduction in the cargo handling cost, that for the construction cost only is considered here, and is shown in Table-V.6.6.

6-4 Shadow Pricing

6-4-1 Method of Estimating Shadow Prices

In estimating all benefits and costs, the shadow pricing is adopted. The method of estimating shadow prices is as follow:

a) All benefits and costs are to be divided into labor, traded goods and non-traded goods.
b) Further, the labor is to be divided into skilled labor and unskilled labor. The price of skilled labour is obtained by multiplying its market price by a conversion factor for consumption (CFC) and the price of unskilled labour is calculated by multiplying its market price by a ratio of a shadow wage rate and a conversion factor for consumption (CFC).
c) Traded goods are to be expressed by CIF value for import and by FOB value for export.
d) Prices for non-traded goods are to be derived by multiplying appropriate conversion factors.

6-4-2 Standard Conversion Factor, Conversion Factor for Consumption, and Other Conversion Factor

(1) Standard Conversion Factor

As will be seen later, the standard conversion factor (SCF) is not used in calculations, but SCF is computed for the following two reasons. The one is to compare the conversion factor for consumption (CFC) with SCF, and the other is to show that tea and rubber are excluded in calculating SCF due to the reason described below. The standard conversion factor SCF is calculated by the following formula since there is no direct export subsidies.

$$SCF = \frac{\text{Total import} + \text{Total export}}{\text{Total import} + \text{Total import duties} + \text{Total export} - \text{Total export duties}}$$

Statistics on the export and the import are shown in Table-V.6.14.

By making calculations using the figures shown in the Table, the following SCFs are obtained:

1977 :	SCF = 1.005
First half of 1978 :	SCF = 1.104

Generally, standard conversion factors in the developing countries are less than 1.0. The SCFs above obtained are a little higher than unity and this is mainly due to the fact that the rates of the export duties for tea and rubber, whose shares in export are about 70%, are high.

Since a standard conversion factor is used mainly for converting the prices of non-traded goods included in the construction cost or operation/maintenance cost it appears to be not appropriate to use a standard conversion factor derived from calculations where tea and rubber are dominant.

SCFs obtained by excluding tea and rubber are as follows:

1977:	SCF = 0.944
First half of 1978:	SCF = 0.943

As a standard conversion factor, the following rounded figure is finally adopted:

SCF = 0.945

(2) Conversion Factor for Consumption

Custom statistics on main consumer goods, such as food and clothing, are shown in Table-V.6.18. From this table, the conversion factor for consumption is calculated by using the similar formula used for the standard conversion factor, and the following results are obtained, excluding tea and rubber:

1977:	CFC = 0.947
First half of 1978:	CFC = 0.948

The conversion factor for consumption is determined as follows:

CFC = 0.945

(3) Conversion Factor for Machinery

A conversion factor for general machinery and vehicles is calculated here in the same manner as is used for the standard conversion factor. Custom statistics used for calculations are shown in Table-V.6.19. Using the figures given in the Table, the conversion factors for machinery (CFM) are calculated as follows:

1977:	CFM = 0.818
First half of 1978:	CFM = 0.855

As a CFM, the following figure is employed in the analysis:

CFM = 0.850

6-4-3 Shadow Wage Rate

There are, in general, two kinds of formulations for determining a shadow wage rate. Here, the following formulation is used for calculations:

$$SWR = C - (C\text{-}m)/S \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

where, SWR: Shadow wage rate
C : Wage in market price
m : Opportunity cost
S : Premium of saving (or investment)

The first term of the equation (1) shows the decrease in savings by the public sector due to payment for wages at market price and the second term indicates the amount consumed by labourers (C-m) as a result of implementation of a project, and is evaluated in terms of saving.

(1) Estimate of Opportunity Cost

The opportunity cost is estimated in many cases from GDP per worker in agriculture sector. But, here, in addition to this method, the minimum wage in the agricultural sector, the wage of the labor employed by a paddy formhold, and the output per worker obtainable from the yield of paddy are calculated, and they are considered integrally.

a) Minimum Wage of Agriculture Sector

As shown in Table-2.16, the minimum wage of the agriculture sector in 1978 is 8.84 Rupees per day. This is for all labors from cultivation to processing to final products of tea, rubber and coconuts. The 1979 price is 10.17 Rupees per day or 0.651 US$.

b) Wages of Employed Labor of Paddy Framers

Wages are calculated from the results of a paddy farm survey conducted in the Colombo District, including the project site as a part of survey for five selected districts in 1972 by Agrarian Research and Training Institute.*

It is known that the Colombo District has the lowest productivity in paddy farming. Typical paddy farmers in Colombo District employed an average of 0.8 workers per acre for paddy farming during Yala season (April to September) in 1972, and the worker's wage is 120 to 180 Rupees per acre, including food expenses. The Yala season consists of a sowing season from April to May, a replanting season from May to June, and a harvesting season in August. Assuming that a worker is employed for 3 months during this season, and works 25 days each month, his wage is calculated as 2 to 3 Rupees per day in 1972, or 6.99 to 10.48 Rupees per day = 0.447 to 0.671 US$ per day in 1979 prices.

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* The Agrarian Situation Relating to Paddy Cultivation in Five Selected Districts of Sri Lanka, Part 5 – Colombo District, Agrarian Research and Training Institute, Research Study Series No. 10, Oct., 1975.

c) Output per Worker Calculated from Yield of Paddy

The yield of paddy per acre is about 45 to 50 bushels according to Table-2.6. The price of paddy is considered to be 51.99 Rupees/bushel here by multiplying 50.79 Rupees/bushel in 1978 by the rate of price rise of 1.02 in 1978 for paddy in accordance with the Guaranteed Price Scheme. If the amount of production is assumed to be 45 bushels, then the output per acre is given as 2,340 Rupees. Since the share of labor force per acre is 42.7%* including family labor during Yala season in 1972, the portion of labour cost then becomes 999 Rupees, if this share is used. By using a total number of workers of 120 to 300 person-days/year*, 8.33 to 3.33 Rupees/day is obtained for 1978, or 9.57 to 3.83 Rupees/day=0.612 to 0.245 US$/day after converted to the 1979 prices.

However, the number of workers, 120 to 300 person-days/year, shown above is an estimation for the number of available workers so that it does not necessary indicate actually employed workers, and this means that there might be a possible overestimation in the above results.

d) Estimate by GDP of Agriculture Sector

GDP of agriculture sector (including forestry and fisheries) is 9,325 million Rupees in 1977. Since the number of workers in agriculture sector is $2,689 \times 10^3$ persons (from Production Yearbook 1977, FAO), 11.56 Rupees/day is obtained for 25 working days per month, which is 18.66 Rupees/day or 1.194 US$ if converted to 1979 prices.

The above results are compiled and indicated in Table-V.6.17. From the results shown above, an opportunity cost of o.5 US$/day is finally adopted.

(2) Estimate on the Premium S of Saving/Investment

The premium S is estimated by the following equation:

$$S = \frac{(1-\theta)\gamma}{i-\theta\gamma}$$

where θ : Rate of saving/investment

γ : Rate of return of marginal investment, and

i : Social discount rate

For θ, 16.8% of the 1978 value shown in Table-2.5 is used.

For γ, 20% is used, in consideration of present level (18% for 1-year) of interest rate for saving in Sri Lanka. Then assuming that i=10%, the premium S is given as 2.5. The premium S thus obtained might include substantial error. However, it is considered more appropriate to evaluate the second term in equation (1), though the evaluation is rather rough, than to evaluate the shadow wage rate only by an opportunity cost.

* The Agrarian Situation Relating to Paddy Cultivation in Five Selected Districts of Sri Lanka, Agrarian Research and Training Institute, Research Study Series No. 11, Dec., 1975.

(3) Estimate of Shadow Wage Rate

Though the market wage C is 18 Rupees/day or 1.152 US$/day, 27 Rupees/day = 1.728 US$/day is used since a short-term employment condition is involved in the implementation of the Plan. Thus, the percentage of the shadow wage rate for the modification of labour cost of the civil engineering work is different from that of benefit items. The results of calculations for the shadow wage rate by using Eq.(1) are shown in Table-V.6.21 for each case. In the same table the ratios of the shadow wage rates to the wage in the market price, obtained by multiplying the conversion factor for consumption, are shown, as well.

6-4-4 Shadow Prices of Benefit Items

(1) Reduction in Cargo Handling Cost

Conversion factors for labour cost are as follows:

Conversion factor for skilled labour
= Conversion factor for consumption = 0.945
Conversion factor for unskilled labor
= (Conversion factor for consumption)
x (Ratio of shadow wage rate (long-term employment)
= 0.945 x 0.773 = 0.730

Since the operation/maintenance cost contains many elements whose details are unknown, in advance, such as repair cost, a simple average of the three conversion factors for consumption, for fuel, and for machinery is employed here as a conversion factor for this cost. Concerning fuel, no custom duties are imposed on the import of crude oil. On the contrary, a large amount of subsidy is being paid to the Ceylon Petroleum Corporation (about 530 million Rupees in 1979). For this reason, the price of fuel in this country is comparatively low and not too much different from the CIF price. Thus, a conversion factor of 1.0 is finally employed for fuel.

Conversion factor for operation/maintenance cost is (0.945 + 1 + 0.850)/3 = 0.932.

Using the above results, the cargo handling costs per ton shown in Table-V.6.6 are converted to the shadow prices and shown in Table-V.6.22.

From the results shown above, the amounts of reduction in cargo handling cost are obtained as shown in Table-V.6.23.

(2) Reduction in Ships' Staying Cost

This itself is expressed in terms of the shadow price.

(3) Value Added Earned by the Colombo Dockyard Ltd.

This includes the receipt in foreign currency and it itself is considered here as the shadow price.

6-4-5 Shadow Prices of the Cost Items

(1) Construction Cost

The conversion factor for skilled labor is 0.945, exactly the same as the conversion factor for consumption.

While, the following is to be employed for unskilled labour.

Conversion factor for unskilled labor
= (Coversion factor for consumption)
x (Ratio of shadow wage rate (short-term employment)
= 0.945 x 0.716 = 0.677

For the conversion factor for fuel, a value of 1.0 will be taken, as is discussed before.

The rent for construction machinery consists of rent for various machinerys and crafts such as dredgers, paving machinerys, dump trucks, concrete mixing plants, etc., and are governed by various factors, such as types of machines, depreciaiton method, etc.

Hence, it appears difficult to evaluate the individual shadow price with acceptable accuracy.

Thus, the entire cost is converted as a whole by making use of the conversion factor for machinery already calculated as 0.850. The shadow prices of the construction costs are shown in Table-V.6.24.

(2) Cost of Purchasing Cargo Handling Equipment

Cargo handling equipment is based on the CIF price as indicated in Table-V.6.15.

(3) Operation/Maintenance Cost

The operation/maintenance cost is calculated by a fixed percentage of the construction cost. Thus, it is possible to convert in the same manner used in the conversion of the construction cost itself. Here, however, the conversion is not applied, considering that the fixed percentage itself contains some ambiguity.

6-5 Economic Returns

(1) Internal Rate of Return

There are many different viewpoints concerning evaluation of the economic returns. Here, however, the economic returns are evaluated in terms of the internal rate of return (IRR).

The internal rate of return IRR is obtained by the following equation:

$$\sum_{i=0}^{n-1} \frac{B_i - C_i}{(1 + IRR)^i} + \frac{R}{(1+IRR)^{n-1}} = 0$$

where
- n : Period of calculating IRR
- B_i: Total amount of benefits at i-th year
- C_i: Total amount of costs at i-th year, and
- R : Salvages at the final year of the calculation

In the present case, the service lifes of facilities and equipment vary individually as shown in the next chapter. The average service life weighted by individual costs is 27.9 years. The calculations are worked out for the period of 25 years from 1980 to 2004. All the benefits and costs for each year are listed in Table-V.6.25(a) and (b). Table-V.6.25(a) shows those in the shadow prices, while Table-V.6.25(b) shows the market prices. From these figures, IRRs with the feedback ratio of 10% are calculated and results are as follows:

For shadow pricing: IRR = 17.1%
For market pricing: IRR = 19.5%

IRRs with the feedback ratio of 50% are 40.8% for shadow pricing and 43.1% for market pricing as shown in Table-V.6.26 (a) and (b).

(2) Feasibility of the Urgent Plan

There are various viewpoints concerning an internal rate of return and economic returns of a project. The internal rates of return in port investment projects usually range from 10% to 20% and it is widely considered that a port project with an internal rate of return of more than, say, 10% can be considered as economically feasible.

Thus, it can be concluded that the present plan has economically enough feasibility.*

The IRRs with the feedback ratio of 50% are remarkably high. For this, there are two main reasons. One is that the Plan includes only such facilities and equipment as can get earnings. The other is that the cargo handling in the WITHOUT case depends not only on the poor cargo handling productivity at alongside berths but also on the unacceptable productivity of midstream berths under the heavy port congestion.

* The IRRs for the ship replacement project of the CSC fleet now under implementation are 6.8% to 9.7%.

Table – V.6.1 Index Numbers of Minimum Wages, Per Capita GNP and Colombo Consumers' Price

Year	Minimum Wages			Per Capita GNP at Current Factor Cost Prices	Colombo Consumers Price
	Agriculture	Non-Agriculture	Combined		
1972	100	100	100	100	100
1973	113.2	110.1	112.7	119.0	109.7
1974	141.4	129.9	139.8	152.4	123.2
1975	176.8	151.6	173.3	166.5	131.5
1976	207.1	155.6	201.6	179.8	133.1
1977	216.5	169.1	210.1	213.6	134.7
1978	303.8	208.1	291.1	259.7	151.1

Source: Statistical Pocket Book, 1978 and 1979, Dept. Census and Statistics
Economic & Social Statistics of Sri Lanka, Central Bank of Ceylon
Annual Report, 1978, Central Bank of Ceylon.

Table – V.6.2 CSC's Share in Dry Cargo

	Cargo Brought by CSC	
	Tonnage	CSC's Share (%)
UK/Continent*1	174,765	43.7
China*2	92,307*3	50.0
Japan/S. Korea/Hong Kong*2	76,159	45.5
Singapore*1	16,849	n.a
Red Sea*2	18,600	31.0
Gulf*2	1,120	n.a
Total	379,800	12.9*4~13.9*5

*1 1978
*2 1977
*3 Rice and Sugar in Metric Tons
*4 % to the 1978 total tonnage
*5 % to the 1977 total tonnage

Source: Report on Survey of Port Improvement Programme (Ship Replacement) of Democratic Socialist Republic of Sri Lanka, August 1979, JICA.

Table – V.6.3 Cargo Handling Cost, Total per Tonnage – 1978

Items	Unit	Total	Labour Cost		Operation/ Maintenance Cost
			Skilled Labour	Unskilled Labour	
Value	US$ Thousand	8,255	3,973	3,973	309
Cost per ton, Overall	US$/t	2.80	1.35	1.35	0.10
Cost per ton, Alongside	US$/t	2.22	1.09	1.09	0.04
Cost per ton, Midstream	US$/t	7.78	3.61	3.61	0.56

Table – V.6.4 Indicators of Cargo Handling Productivity

	WITHOUT	WITH
Gang Hour Productivity		
Food	20.1 t/gang·h	20.1 t/gang·h
General Cargo	8.3 〃	15.0 〃 (General Cargo and Export)
Export	9.0 〃	
No. of Gangs per Vessel		
Food	2.8 gangs	4.0 gangs (Food, General Cargo and Export)
General Cargo	2.8 〃	
Export	2.5 〃	
Rate of Berth Occupancy	100 %	73 %

Table – V.6.5 Cargo Handling Cost per Ton after Completion of Urgent Plant

(Unit: US$/Tons)

	Total	Labour Cost		Operation/ Maintenance Cost
		Skilled	Unskilled	
After Introducing Equipment	1.77	0.78	0.78	0.21
Container (QEQ)	1.59	0.78	0.20	0.61
Container (KQ)	1.14	0.42	0.13	0.59

Table – V.6.6 Cargo Handling Cost per Ton (1979 Value)

(Unit: US$/Tons)

Item		Total	Labour Cost		Operation/ Maintenance Cost
			Skilled	Unskilled	
1978	Overall	3.21	1.55	1.55	0.11
	Alongside Berth	2.54	1.25	1.25	0.04
	Midstream Berth	8.94	4.15	4.15	0.64
After Introducing Equipment		2.01	0.90	0.90	0.21
Container (QEQ)		1.74	0.90	0.23	0.61
Container (KQ)		1.22	0.48	0.15	0.59

Table – V.6.7 Yearly Tonnage of Cargo Assumed by Facility

(Unit: Thousand Tons)

	Total	WITHOUT		WITH		
		Alongside Berth	Midstream Berth	Alongside Conventional	QEQ Container	KQ Container
1981	3,114	2,700	414	3,114	–	–
1982	3,285	↓	585	2,785	500	–
1983	3,313		613	2,813	500	–
1984	3,450		750	2,200	250	1,000
1985	3,550		850	↓	350	↓
1986	3,650		950		450	
1987	3,700		1,000		500	
1988	↓		↓		↓	

Table – V.6.8 Reduction in Cargo Handling Cost

Year	Value Reduced (Thousand US$)
1981	4,300
1982	5,620
1983	5,814
1984	7,486
1985	8,206
1986	8,926
1987	9,286
1988	↓

Table – V.6.9 Average Awaiting Period/Average Working Period

(Unit: Days)

Year	WITHOUT			WITH					
				Conventional			Container		
	Average Awaiting Period	Average Working Period	Total	Average Awaiting Period	Average Working Period	Total	Average Awaiting Period	Average Working Period	Total
1978	1.70	5.87	7.57	–	–	–	–	–	–
1980	1.73	5.98	7.71	1.73	5.98	7.71	–	–	–
1981	1.77	6.09	7.86	1.70	3.76	5.46	–	–	–
1982	1.83	6.30	8.13	1.70	3.85	5.55	0.60	1.00	1.60
1983	1.84	6.33	8.17	1.70	3.79	5.49	0.60	│	1.60
1984	1.88	6.47	8.35	0.32	3.99	4.31	0.40	│	1.40
1985	1.91	6.57	8.48	0.31	3.86	4.17	0.55	│	1.55
1986	1.93	6.67	8.60	│	3.87	4.18	0.75	│	1.75
1987	1.95	6.71	8.66	│	3.90	4.21	0.90	│	1.90
1988	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table – V.6.10 Reduction in Ships' Staying Period

Year	WITHOUT			WITH							WITHOUT less WITH (Vessel-Days)
							Container			Grand Total (Vessel-Days)	
	No. of Vessels	Average Days of Stay	Total (Vessel-Days)	No. of Vessels	Average Days of Stay	Total (Vessel-Days)	No. of Vessels	Average Days of Stay	Total (Vessel-Days)		
1980	1,465	7.71	11,295	1,465	7.71	11,295				11,295	0
1981	1,543	7.86	12,128	1,543	5.46	8,425				8,425	3,703
1982	1,638	8.13	13,317	1,344	5.55	7,459	196	1.60	314	7,773	5,544
1983	1,677	8.17	13,701	1,315	5.49	7,219	196	1.60	314	7,533	6,168
1984	1,755	8.35	14,654	1,020	4.31	4,396	490	1.40	686	5,082	9,572
1985	1,851	8.48	15,696	1,057	4.17	4,408	529	1.55	820	5,228	10,468
1986	1,849	8.60	15,901	1,055	4.18	4,410	569	1.75	996	5,406	10,495
1987	1,928	8.66	16,696	1,046	4.21	4,404	588	1.90	1,117	5,521	11,175
1988	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table – V.6.11 Time Charterage of Dry Cargo Vessels

(Unit: US$/DWT·Month)

Year	25,000 DWT (About)	40,000 DWT (About)	Panamax (65,000 DWT About)
1973	9.00 ~ 4.00	6.80 ~ 3.27	5.90 ~ 3.20
1974	9.25 ~ 4.70	5.85 ~ 5.675	5.75 ~ 3.20
1977	6.90 ~ 3.25	3.25 ~ 1.98	2.60 ~ 0.95
1978	5.95 ~ 4.25	4.42 ~ 3.37	3.20 ~ 0.875
1979 Jan. ~ Mar.	8.10 ~ 4.85	5.30	3.65 ~ 2.90
" April	7.00 ~ 5.50	4.17	–
" May	8.03 ~ 5.75	5.25	5.25 ~ 3.10
" June	9.04 ~ 7.58	5.24	5.25
" July	7.77	6.21	5.35 ~ 4.90
" August	8.05 ~ 7.12	5.99	5.25 ~ 3.75
" September	7.85 ~ 7.38	6.37	–
" October (Until the 2nd Week)	–	6.62	5.90 ~ 5.40
Average	6.16	4.58	3.43

Table – V.6.12 Reduction in Ships' Staying Cost

Year	Feedback Ratio = 10%	Feedback Ratio = 50%
1980	0	0
1981	1,111	5,555
1982	1,663	8,316
1983	1,850	9,252
1984	2,872	14,358
1985	3,140	15,702
1986	3,149	15,743
1987	3,353	16,763
1988	↓	↓

Table – V.6.13 Value Added – CDL, 1978

Item	Thousand Rs.	Share (%)
Turnover	40,209	
Other Income	1,351	
Total	41,560	100
Cost of Materials and Services purchased	17,671	42.5
Depreciation	2,373	5.7
Value added	21,516	51.8
To Employees	6,421	
To Government	6,463	
Profits retained	8,632	

Source: Colombo Dockyard Limited, Annual Report 1978

Table – V.6.14 Composition of Construction Cost

(Unit: Thousand US$)

	Total	1980	1981	1982	1983
Total	49,127	877	13,561	14,960	19,729
Foreign Currency	32,709	683	9,810	11,450	10,766
Local Currency	16,418	194	3,751	3,510	8,963
Labour Cost	2,851	19	813	878	1,141
Skilled	2,180	19	625	676	860
Unskilled	671	0	188	202	281
Fuel	2,771	0	578	648	1,545
Hire of Equipment and Others	10,796	175	2,360	1,984	6,277

Table – V.6.15 Cost of Cargo/Container Handling Equipment

(Unit: Thousand US$)

	Total	1980	1981	1982	1983
Total	21,331	7,537	4,461	0	9,333
QEQ	4,461	0	4,461	0	0
KQ	9,333	0	0	0	9,333
Conventional Berth	7,537	7,537	0	0	0

Tabel – V.6.16 Operation/Maintenance Cost

(Unit: Thousand US$)

Year	Operation/ Maintenance Cost
1980	0
81	0
82	30
83	30
84	351
85	1

Table – V.6.17 Custom Statistics

(Unit: Million Rs.)

	1977	1978 (Jan.~June)
Import	6,012	6,855
Import Duty Revenue	541	696
Export	6,615	6,182
Export Duty Revenue	609	1,924
Export except Tea/Rubber	1,974	1,807
Export Duty Revenue except those for Tea/Rubber	69	171

Source: External Trade Statistics, Dec. 1977 and June 1978, Sri Lanka Customs.

Table – V.6.18 Custom Statistics on Main Consumer Goods

(Unit: Million Rs.)

	1977	1978 (Jan.~June)
Import	2,862	2,876
Import Duty Revenue	225	223
Export	504	596
Export Duty Revenue	36	27

Source: External Trade Statistics, Dec. 1977 and June 1978, Sri Lanka Customs.

Table – V.6.19 Custom Statistics on Machinery/Vehicle

(Unit: Thousand Rs.)

	1977	1978 (Jan.~June)
Import	707	1,404
Import Duty Revenue	160	239
Export	12	10
Export Duty Revenue	0	0

Source: External Trade Statistics, Dec. 1977 and June 1978, Sri Lanka Customs.

Table – V.6.20 Estimations of Shadow Wage Rate

(Unit: US$/Day)

Method	Estimated Shadow Wage Rate
Minimum Wage of Agricultural Sector	0.651
Estimate from Paddy Production	0.612 ~ 0.245
Wage of Hired Labour (Paddy Farm)	0.671 ~ 0.447
Estimate from GDP (Agricultural Sector)	1.194

Table – V.6.21 Shadow Wage Rate and Its Ratio to Market Price

	Shadow Wage Rate (US$/Day)	Ratio to Market Price
Full-Time, Long Term	0.591	0.773
Full-Time, Temporary	1.237	0.716

Table – V.6.22 Cargo Handling Cost per Ton (Shadow Price)

(Unit: US$/Tons)

		Total	Labour Cost		Operation/ Maintenance Cost
			Skilled	Unskilled	
1978	Over-All	2.69	1.46	1.13	0.10
	Alongside Berth	2.13	1.18	0.91	0.04
	Midstream Berth	7.55	3.92	3.03	0.60
After Introducing Equipment (Conventional)		1.71	0.85	0.66	0.20
Container (QEQ)		1.59	0.85	0.17	0.57
Container (KQ)		1.11	0.45	0.11	0.55

Table – V.6.23. Reduction of Cargo Handling Cost (Shadow Price)

Year	Value Reduced (Thousand US$)
1980	0
1981	3,552
1982	4,611
1983	4,774
1984	6,144
1985	6,740
1986	7,336
1987	7,634
1988	↓

Table – V.6.24. Construction Cost (Shadow Price)

Year	Construction Cost (Thousand US$)
1980	850
1981	13,112
1982	14,560
1983	18,649

Table – V.6.25 (a) Costs/Benefits and IRR – Shadow Price
IRR=17.1%

(Unit: Thousand US$)

No.	Year	Costs				Benefits				Salvage	Present Value (Discount Rate=17.1%)
		Total	Construction	Equipment	Operation/ Maintenance	Total	Reduction in Cargo Handling Cost	Reduction in Ships' Staying Cost	Value Added, CDL		
1	1980	8,387	850	7,537							△ 8,387
2	1981	17,573	13,112	4,461		4,663	3,552	1,111			△11,025
3	1982	14,590	14,560	0	30	6,274	4,611	1,663			△ 6,065
4	1983	28,012	18,649	9,333	30	6,624	4,774	1,850			△13,320
5	1984	351			351	9,793	6,144	2,872	777		5,022
6	1985	351			351	10,657	6,740	3,140	777		4,681
7	1986	351			351	11,262	7,336	3,149	777		4,232
8	1987	351			351	11,764	7,634	3,353	777		3,780
9	1988	351			351	11,764	7,634	3,353	777		3,228
10	1989	351			351	11,764	7,634	3,353	777		2,757
11	1990	351			351	11,764	7,634	3,353	777		2,354
12	1991	351			351	11,764	7,634	3,353	777		2,010
13	1992	351			351	11,764	7,634	3,353	777		1,717
14	1993	351			351	11,764	7,634	3,353	777		1,466
15	1994	351			351	11,764	7,634	3,353	777		1,252
16	1995	351			351	11,764	7,634	3,353	777		1,069
17	1996	351			351	11,764	7,634	3,353	777		913
18	1997	351			351	11,764	7,634	3,353	777		780
19	1998	351			351	11,764	7,634	3,353	777		666
20	1999	351			351	11,764	7,634	3,353	777		569
21	2000	351			351	11,764	7,634	3,353	777		486
22	2001	351			351	11,764	7,634	3,353	777		415
23	2002	351			351	11,764	7,634	3,353	777		354
24	2003	351			351	11,764	7,634	3,353	777		302
25	2004	351			351	11,764	7,634	3,353	777	23,552	791
Total		75,933	47,171	21,331	7,431	261,025	170,569	74,139	16,317	23,552	47

Table – V.6.25 (b) Costs/Benefits and IRR – Market Price
IRR=19.5%

(Unit: Thousand US$)

	Year	Costs				Benefits				Salvage	Present Value (Discount Rate=19.5%)
		Total	Con-struction	Equipment	Operation/ Maintenance	Total	Reduction in Cargo Hand-ling Cost	Reduction in Ships' Stay-ing Cost	Value Added, CDL		
1	1980	8,414	877	7,537							△ 8,414
2	1981	18,022	13,561	4,461		5,411	4,300	1,111			△10,553
3	1982	14,990	14,960	0	30	7,283	5,620	1,663			△ 5,397
4	1983	29,092	19,729	9,333	30	7,664	5,814	1,850			△12,557
5	1984	351			351	11,135	7,486	2,872	777		5,288
6	1985	351			351	12,123	8,206	3,140	777		4,831
7	1986	351			351	12,852	8,926	3,149	777		4,293
8	1987	351			351	13,416	9,286	3,353	777		3,754
9	1988	351			351	13,416	9,286	3,353	777		3,142
10	1989	351			351	13,416	9,286	3,353	777		2,629
11	1990	351			351	13,416	9,286	3,353	777		2,200
12	1991	351			351	13,416	9,286	3,353	777		1,841
13	1992	351			351	13,416	9,286	3,353	777		1,541
14	1993	351			351	13,416	9,286	3,353	777		1,289
15	1994	351			351	13,416	9,286	3,353	777		1,079
16	1995	351			351	13,416	9,286	3,353	777		903
17	1996	351			351	13,416	9,286	3,353	777		755
18	1997	351			351	13,416	9,286	3,353	777		632
19	1998	351			351	13,416	9,286	3,353	777		529
20	1999	351			351	13,416	9,286	3,353	777		443
21	2000	351			351	13,416	9,286	3,353	777		370
22	2001	351			351	13,416	9,286	3,353	777		310
23	2002	351			351	13,416	9,286	3,353	777		259
24	2003	351			351	13,416	9,286	3,353	777		217
25	2004	351			351	13,416	9,286	3,353	777	23,552	509
Total		77,889	49,127	21,331	7,431	297,956	207,500	74,139	16,317	23,552	△ 107

Table – V.6.26 (a) Costs/Benefits and IRR – Shadow Price
IRR=40.8%

(Unit: Thousand US$)

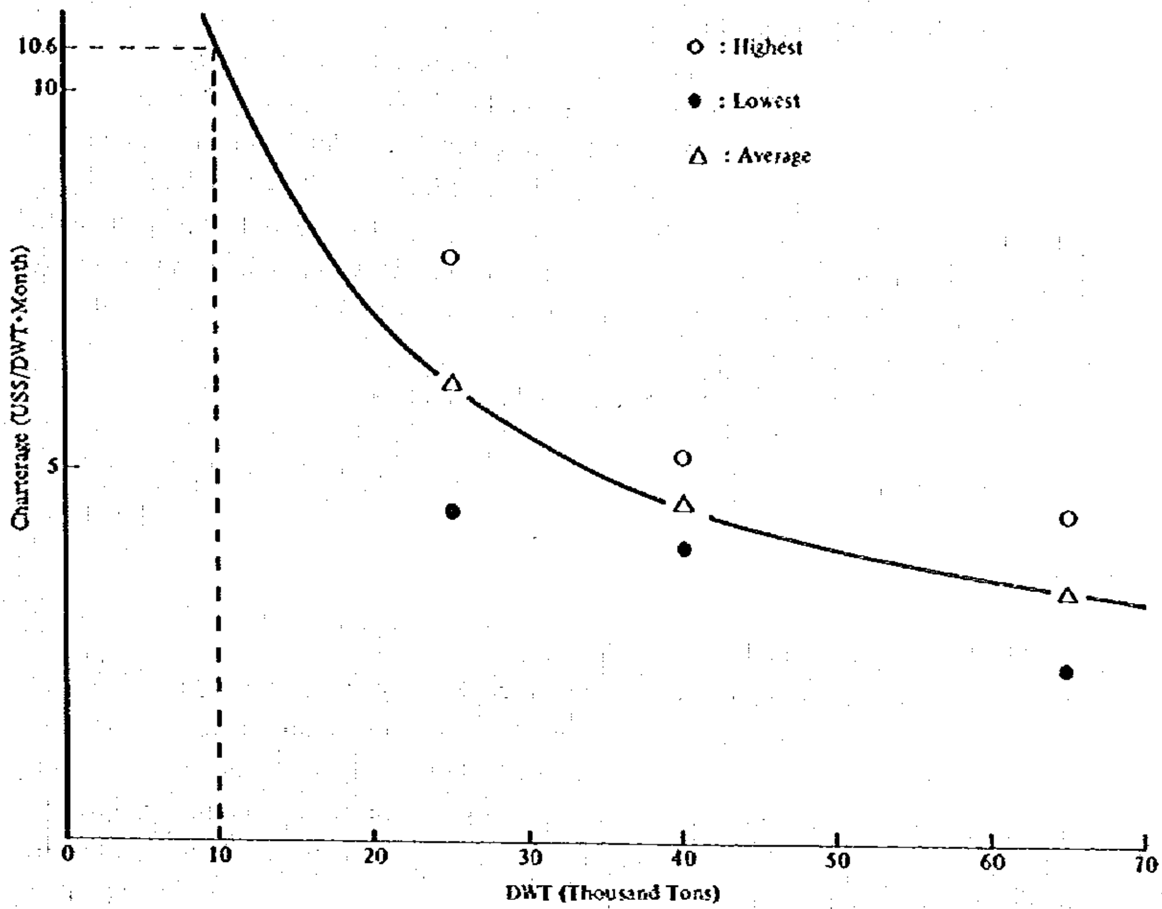
No.	Year	Costs				Benefits				Salvage	Present Value (Discount Rate=40.8%)
		Total	Construction	Equipment	Operation/ Maintenance	Total	Reduction in Cargo Handling Cost	Reduction in Ships' Staying Cost	Value Added, CDL		
1	1980	8,387	850	7,537							△ 8,387
2	1981	17,573	13,112	4,461		9,107	3,552	5,555			△ 6,013
3	1982	14,590	14,560	0	30	12,927	4,611	8,316			△ 839
4	1983	28,012	18,649	9,333	30	14,026	4,774	9,252			△ 5,011
5	1984	351			351	21,279	6,144	14,358	777		5,325
6	1985	351			351	23,219	6,740	15,702	777		4,132
7	1986	351			351	23,856	7,336	15,743	777		3,017
8	1987	351			351	25,174	7,634	16,763	777		2,263
9	1988	351			351	25,174	7,634	16,763	777		1,607
10	1989	351			351	25,174	7,634	16,763	777		1,141
11	1990	351			351	25,174	7,634	16,763	777		811
12	1991	351			351	25,174	7,634	16,763	777		576
13	1992	351			351	25,174	7,634	16,763	777		409
14	1993	351			351	25,174	7,634	16,763	777		290
15	1994	351			351	25,174	7,634	16,763	777		206
16	1995	351			351	25,174	7,634	16,763	777		146
17	1996	351			351	25,174	7,634	16,763	777		104
18	1997	351			351	25,174	7,634	16,763	777		74
19	1998	351			351	25,174	7,634	16,763	777		52
20	1999	351			351	25,174	7,634	16,763	777		37
21	2000	351			351	25,174	7,634	16,763	777		26
22	2001	351			351	25,174	7,634	16,763	777		19
23	2002	351			351	25,174	7,634	16,763	777		13
24	2003	351			351	25,174	7,634	16,763	777		9
25	2004	351			351	25,174	7,634	16,763	777	23,552	13
Total		75,933	47,171	21,331	7,431	557,546	170,569	370,660	16,317	23,552	20

Table – V.6.26 (b) Costs/Benefits and IRR – Market Price
IRR=43.1%

(Unit: Thousand US$)

No.	Year	Costs				Benefits				Salvage	Present Value (Discount Rate=43.1%)
		Total	Con-struction	Equipment	Operation/ Maintenance	Total	Reduction in Cargo Hand-ling Cost	Reduction in Ships' Stay-ing Cost	Value Added, CDL		
1	1980	8,414	877	7,537							△ 8,414
2	1981	18,022	13,561	4,461		9,855	4,300	5,555			△ 5,707
3	1982	14,990	14,960	0	30	13,936	5,620	8,316			△ 515
4	1983	29,092	19,729	9,333	30	15,066	5,814	9,252			△ 4,786
5	1984	351			351	22,621	7,486	14,358	777		5,311
6	1985	351			351	24,685	8,206	15,702	777		4,055
7	1986	351			351	25,446	8,926	15,743	777		2,922
8	1987	351			351	26,826	9,286	16,763	777		2,155
9	1988	351			351	26,826	9,286	16,763	777		1,506
10	1989	351			351	26,826	9,286	16,763	777		1,052
11	1990	351			351	26,826	9,286	16,763	777		735
12	1991	351			351	26,826	9,286	16,763	777		514
13	1992	351			351	26,826	9,286	16,763	777		359
14	1993	351			351	26,826	9,286	16,763	777		251
15	1994	351			351	26,826	9,286	16,763	777		175
16	1995	351			351	26,826	9,286	16,763	777		123
17	1996	351			351	26,826	9,286	16,763	777		86
18	1997	351			351	26,826	9,286	16,763	777		60
19	1998	351			351	26,826	9,286	16,763	777		42
20	1999	351			351	26,826	9,286	16,763	777		29
21	2000	351			351	26,826	9,286	16,763	777		20
22	2001	351			351	26,826	9,286	16,763	777		14
23	2002	351			351	26,826	9,286	16,763	777		10
24	2003	351			351	26,826	9,286	16,763	777		7
25	2004	351			351	26,826	9,286	16,763	777	23,552	9
Total		77,889	49,127	21,331	7,431	594,477	207,500	370,660	16,317	23,552	13

Fig. – V.6.1 Time Charterage of Dry Cargo Vessel



CHAPTER 7 FINANCIAL ANALYSIS

7-1 Assumptions and Others

In making the financial analysis in this chapter, it is assumed that the Port of Colombo alone is managed as a self supporting enterprise, although the Sri Lanka Ports Authority owns, controls and manages not only the Port of Colombo but also the Ports of Galle and Trincomalee.

The scope of the financial analysis may be limited to the project itself, but in consideration of the scale of this project compared to that of the existing Port, it is finally judged to be more appropriate to review the revenue and expenditure, source and application of funds, and financial condition of the entire Port as a whole.

The calculations in this chapter are made in terms of local currency.

7-2 Fixed Assets and Depreciation

7-2-1 Fixed Assets

(1) Estimate on the Value of Existing Fixed Assets

The Sri Lanka Ports Authority is a body corporate organized by amalgamating the Colombo Port Commission, the Port (Cargo) Corporation and the Port Tally and Protective Services Corporation. Both the Port (Cargo) Corporation and the Port Tally and Protective Services Corporation had been employing a business accounting system for their accounting, but the Colombo Port Commission had not since it was a division of the government. At present, the Sri Lanka Ports Authority is conducting a revaluation of the fixed assets of the former Colombo Port Commission. Under such circumstances, there is no alternative but to estimate the value of the fixed assets of the Port of Colombo at the end of 1978 as indicated in the following for the financial analysis.

1) Estimate on the value of fixed assets of the Colombo Port Commission Section

Only the land and the assets of the extension work of the Queen Elizabeth Quay No. 5 having been carried out by the Colombo Port Commission will be counted as fixed assets, because it is considered that the work of the Queen Elizabeth Quay No. 5 is the only large investment made in recent years.

In appraising the land, lands within the Port and lands owned in surrounding vicinity are evaluated as follows basing upon the land prices in adjacent areas:

Land in port area:

33,840 perch x Rs 30,000/perch ≒ Rs 1,015M

Land in surrounding vicinity:

77,240 perch x Rs 3,000/perch ≒ Rs 232M

Land total ≒ Rs 1,250M

(1 perch = 25.3 m^2, thus, Rs 30,000/perch is Rs 1,186/m^2)

The investment of about Rs. 26 million up to the end of 1978 for the Queen Elizabeth Quay No. 5 extension work, will be counted as the account of construction in process.

2) Estimate on the value of fixed assets of the Port (Cargo) Corporation Section and the Port Tally and Protective Services Corporation Section.
Rs. 20 million (book value adopted as of the end of 1978)

3) Estimate on the value of fixed assets of the Port of Colombo:
Using the above procedure, the fixed assets of the Port of Colombo at the end of 1978 are estimated as follows:

Land:	Rs 1,250 million
Assets to be depreciated:	20 million
Construction in process:	26 millions
Total	Rs. 1,296 million

(2) Fixed assets by new investment
Amounts of annual investment of this project and fixed assets by account title are shown in Table-V.7.1.

7-2-2 Depreciation
Since the method of depreciation of the Sri Lanka Ports Authority is under review at this stage, the following method will be adopted in the financial analysis.
In respect to the assets to be depreciated of the new investment, the service life of each facility is assumed as shown in Table-V.7.2, and average service life computed is 27.9 years.
Basing upon this average service life, the amount of annual depreciation is calculated by the straight line method, assuming no residual value. Depreciation equivalent to actual record in 1978 will be considered for the existing facilities. The fixed assets schedule of the Port of Colombo computed is indicated in Table-V.7.3.

7-3 Revenue and Expenditure

7-3-1 Reneue

(1) Estimate on annual tonnage of cargo handled
Annual tonnage of cargo handled in the Port of Colombo for conventional cargo and containers are estimated from Part III "Forecast of Tonnage of Cargo Handled" and Part V-2. "Facility and Equipment Plan" and indicated in Table-V.7.4. Numbers of containers for import and export in TEU are calculated and indicated in Table-V.7.5.
On and after 1987, the annual tonnage of cargo handled and numbers of containers are assumed to be constant.

(2) Classification of revenue items and *unit charge

Using BUDGET-1980 (draft) of the Sri Lanka Ports Authority as reference, the revenue items are generally classified into 4 items; the Colombo Port Commission Section, the Port (Cargo) Corporation Section, the Port Tally and Protective Services Corporation Section and Container Section.

*Unit charge is defined as follows;
in the case of conventional cargo
——— charge per ton
in the case of containers
———charge per TEU
However, for landing & delivery and shipping of Container Section, charges are calculated the same as for conventional cargo.

Though some of the unit charges of the Colombo Port Commission Section are to be correlated to the tonnages of ships, it is considered here that these are proportional to the tonnage of cargo.

From the above, actual records of 1978 are adopted as current unit charges for the Colombo Port Commission Section,the Port (Cargo) Corporation Section, and the Port Tally and Protective Services Corporation Section. For the Container Section the unit charge per TEU is calculated from the Sri Lanka Ports Authority's "Schedule of Charges for Handling Containers" assuming a typical flow of container cargo.

Basing upon the annual tonnage of cargo handled, the estimate of revenue determined by current unit charge of 1983 (the target year) and 1984 is shown in Table-V.7.6.

7-3-2 Expenditure

Expenditure is estimated as shown below by classifying it into personnel expenses, maintenance and operating costs, management costs, business turn-over tax, interests and depreciation costs.

At first, the expenditure in 1978 of the Colombo Port Commission Section is estimated from the Sri Lanka Ports Authority's BUDGET-1980 (draft), it is then added to achieved figures of the Port (Cargo) Corporation Section, and the Port Tally and Protective Services Corporation Section, thus the expenditure of each item of the Port of Colombo in 1978 is determined. Then, based upon these results, the annual expenditure for each item is calculated as shown below for the Port of Colombo as a whole.

Personnel expenses:

It is assumed that total number of employees and labourers will remain the same even after introducing conventional cargo handling equipment and container handling equipment. But an annual increase of 10% is assumed up to 1984, and personnel expenses for both existing facilities and new facilities are combined together for estimating them.

Maintenance and Operating costs:

For existing facilities: These costs were calculated after classifying them into fixed and variable expenses to reflect the actual records.

For new investment: Calculations were made by establishing percentages of maintenance and operating costs to the sum of investment for each facility, as shown in Table-V.7.7.

Management costs:

Basing upon the assumed costs for 1978, costs for both existing facilities and newly invested facilities are estimated together.

Interests: They are estimated yearly for each of cases stated later.

Depreciation: Estimated as shown in chapter 7.2.2.

50% of profit after depreciation will be paid as taxes, and a dividend of 4% per year will be paid for the capital investment by the Government. (Rs. 1,332 million at end of 1978, and Rs. 1,336 million after 1979).

7-4 Review on Level of Unit Charge

7-4-1 Funds Raising

Required funds for this project in foreign currency and local currency are shown below.

Foreign currency:	Rs.	844 million
Local currency:	Rs.	257 million
Total:	Rs.	1,101 million

Concerning the fund raising, it is assumed that long-term loan/loans from foreign country/countries will be made for foreign currency and loan from the Consolidated Fund be made for local currency. In referring to loan terms by international financial institution, such as ADB, 8% interest and a 20-year loan term (including 5-year term of deferment) are assumed. Subsidy or capital investment by the government for the local currency portion is not assumed because of the independent profit system of Port Management. Loan from the Consolidated Fund will be repaid in 15 or 20 years.

7-4-2 Review on Cases

Financial soundness will be reviewed for the three cases as shown in Table-V7.8 in respect to the terms of fund raising and unit charges (charge other than containers):

In all three cases shown in Table-V7.8, 8% interest and 20-year term are assumed for loan/loans from foreign country/countries. In addition to the above, the case as shown in Table-V.7.9 will be also reviewed where terms similar to those of Yen credit recently extended by Japan to Sri Lanka is adopted:

7-4-3 Results of Review

Three financial statements for a project life of 25 years from the investment beginning in the year 1980 and ending in the year 2004 were prepared for each case as shown in Table-V.7.11 "Statement of Revenue and Expenditure", Table-V.7.12 "Statement of Source and Application of Funds", and Table-V.7.13 "Balance Sheet". Operating ratio and return on net fixed assets for each case are shown in Table-V.7.14.

Each case is reviewed hereinafter;

(1) Case A, where current unit charge remains unchanged

This is the case where the local currency funding will be borrowed from the Consolidated Fund without interest. Estimated revenue in 1983 (target year) and 1984 based on the current unit charge is shown in Table-V.7.6. In this case, though profit after depreciation can be expected, there is probably no allowance for paying dividends to the capital investment by the government after taxes are paid, and uses and management of funds may become very difficult to perform if such a dividend is paid. Also on the balance sheet, part of the fixed assets must be obtained in future by using current liabilities, which is not desirable financially.

(2) Case B_1 where the current unit charge is raised by 25%

This is the case where the local currency funding will be borrowed from the Consolidated Fund with 8% interest and 15-year term.

Revenue estimated for 1983 (target year) and 1984 based upon a new unit charge which is 25% higher than current unit charge is shown in Table-V.7.10. (Container charge remains unchanged.)

In this case, a 4% dividend to the capital investment by the government is possible after paying 50% taxes from the profit after depreciation.

Compared to Case A, both operating ratio and return on net fixed assets can be greatly improved in this case.

(3) Case B_2 where the current unit charge is raised by 25%

In this case the terms are more advantageous to the Port of Colombo than in Case B_1 since 4% interest and 20-year term are used instead of 8% and 15-year for Case B_1. But such change in loan terms affects the financial condition only slightly.

Also, from the financial statements for Case C, it is known that a raise of only 18% for the current unit charge will be sufficient if loan/loans with lower interest are available from abroad.

7-4-4 Comments

The current unit charge must be raised by approximately 25%, except for containers, if the independent profit system of the Port of Colombo is to function. However, a lower increase in unit charge is possible if lower interest loan/loans from abroad are available. Even if the current unit charge remains unchanged, it is considered that the management can be possible without difficulty if funds requiring no interest are raised for the local currency portion and dividend to the capital investment by the government is not required.

7-5 Internal Rate of Return (Financial)

The effects of investment for this project is financially reviewed below. All analysis made in the foregoing paragraphs are for the whole of the Port of Colombo. However, the profitability of the project will be judged independently in the analysis made here. Thus, profit before depreciation and before interest payment corresponding to the amount of investment for the project must be calculated for every year. And the estimated amount of profit before depreciation and before interest payment (Rs. 134 million) for the Port of Colombo in 1978 will be deducted from the profit before depreciation and before interest payment of each year after 1981 when investment effects seem to appear, and the result is considered to be the profit before depreciation and before interest payment, which corresponds to the amount of investment of the project of each year.

By using the above method, the financial rate of return (FRR) for Case B_1, calculated on the independent profit system of the Port of Colombo, is 8.22% as shown in Table-V.7.15. The relationship between the percentage raise in unit charge of this project and financial rate of return is shown in Table-V.7.16.

Table – V.7.1 Amounts of Annual Investment and Fixed Assets by Account Title

		1980	1981	1982	1983
Investment		131	282	234	454
(Accumulated Investment)		(131)	(413)	(647)	(1,101)
Items	Land	–	–	–	143
	Assets to be depreciated	118	143	29	698
	Construction in Process a/c	13	139	205	–

Note: The difference of Rs. 30 million between total of Investment and total of Land and Assets to be depreciated is due to construction cost of QEQ #5, which was already invested but will be transfered into Assets to be depreciated of 1981 when construction work is completed.

Table – V.7.2 Service Life of Facilities

items	Service life (years)
Quaywall	50
Revetment	50
Building	35
Power, lighting, water supply	15
Pavement	15
Floating crane	12
Equipment	7

Table – V.7.3 Fixed Assets Schedule

(Unit: Million Rs.)

	1978	1979	1980	1981	1982	1983	1984	1985 ~1989	1990 ~1994	1995 ~1999	2000 ~2004
Fixed Assets at Beginning of Year		1,296	1,298	1,427	1,703	1,926	2,368	2,333	2,158	1,983	1,808
Land		1,250	1,250	1,250	1,250	1,250	1,393	1,393	1,393	1,393	1,393
Assets to be Depreciated		20	18	134	271	289	975	940	765	590	415
Construction in Process a/c		26	30	43	182	387	–	–	–	–	–
Investment		4	131	282	234	454					
(Accumulated Investment)			(131)	(413)	(647)	(1,101)	–	–	–	–	–
Land		–	–	–	–	143	–	–	–	–	–
Assets to be Depreciated		–	118	143	29	698	–	–	–	–	–
Construction in Process a/c		4	13	139	205	–	–	–	–	–	–
Depreciation		2	2	6	11	12	35	175	175	175	175
Fixed Assets at End of Year	1,296	1,298	1,427	1,703	1,926	2,368	2,333	2,158	1,983	1,808	1,633
Land	1,250	1,250	1,250	1,250	1,250	1,393	1,393	1,393	1,393	1,393	1,393
Assets to be Depreciated	20	18	134	271	289	975	940	765	590	415	240
Construction in Process	26	30	43	182	387	–	–	–	–	–	–

Table – V.7.4 Estimate on Tonnage of Corgo Handled Yearly

(Unit: thousand tons)

	1978 (actual)	1979	1980	1981	1982	1983	1984	1985	1986	1987
Dry Cargo Grand Total	2,945	3,093	3,025	3,114	3,285	3,313	3,450	3,550	3,650	3,700
Export	1,050	1,100	1,164	1,235	1,314	1,405	1,440	1,520	1,540	1,540
Import	1,895	1,993	1,861	1,879	1,971	1,908	2,010	2,030	2,110	2,160
Container Cargo										
Export			75	75	250	250	750	750	750	750
Import			75	75	250	250	500	600	700	750
Ex. Im. Total			150	150	500	500	1,250	1,350	1,450	1,500
Transhipment			–	–	–	–	250	150	50	–
Total			150	150	500	500	1,500	1,500	1,500	1,500
Conventional Cargo										
Export	1,050	1,100	1,089	1,160	1,064	1,155	690	770	790	790
Import	1,895	1,993	1,786	1,804	1,721	1,658	1,510	1,430	1,410	1,410
Total	2,945	3,093	2,875	2,964	2,785	2,813	2,200	2,200	2,200	2,200

Table – V.7.5. Estimate on Numbers of Containers (In TEU)

	1980	1981	1982	1983	1984	1985	1986	1987
Export								
FCL	3,520	3,520	11,800	11,800	35,300	35,300	35,300	35,300
LCL	880	880	2,900	2,900	8,800	8,800	8,800	8,800
Total	4,400	4,400	14,700	14,700	44,100	44,100	44,100	44,100
Import								
FCL	3,520	3,520	11,800	11,800	23,500	28,200	33,000	35,300
LCL	880	880	2,900	2,900	5,900	7,100	8,200	8,800
EMPTY	–	–	–	–	14,700	8,800	2,900	–
Total	4,400	4,400	14,700	14,700	44,100	44,100	44,100	44,100
Transhipment	–	–	–	–	7,400	4,400	1,500	–

Notes: 1) Number of containers is calcuated on basis of 17 tons cargo per TEU.
2) Ratio of FCL to LCL is assumed 80/20.
3) For Empty containers, it is assumed that difference between numbers of containers required for export and import is brought into the Port as empty (without cargo)

Table – V.7.6 Estimate on Revenue under Current Tariff

	1978 Actual			1983			1984		
	Revenur per ton Rs./ton	Cargo Tonnage 1,000 tons	Revenue Rs. M.	Revenue per ton Rs/ton	Cargo Tonnage 1,000 tons	Revenue Rs. M.	Revenue per ton Rs./ton	Cargo Tonnage 1,000 tons	Revenue Rs. M.
Port & Harbour Dues	7.8	2,945	23	7.8	3,313	26	7.8	3,450	277
Rents	9.8	2,945	29	9.8	3,313	32	9.8	3,450	34
Pilotages	1.3	2,945	4	1.3	3,313	4	1.3	3,450	4
Quay charges	1.5	2,945	4	1.5	3,313	5	1.5	3,450	5
Others			13			13			13
(C P C section Total)			(73)			(80)			(83)
Stevedoring	53.2	2,945	157	53.2	2,813	150	53.2	2,200	117
Landing & Delivery	56.2	1,895	106	56.2	1,658	93	56.2	1,510	85
Shipping	19.8	1,050	21	19.8	1,155	23	19.8	690	14
Transhipment			1			1			1
Supply of water	2.1	2,945	6	2.1	3,313	7	2.1	3,450	7
Others			8			8			8
(P (C) C section Total)			(299)			(282)			(232)
PTPSC	6.0	2,945	18	6.0	3,313	20	6.0	3,450	21
Sub-Total			(390)			(382)			(336)
				Revenue per TEU Rs./TEU	TEU	Revenue Rs.M.	Revenue per TEU Rs./TEU	TEU	Revenue Rs. M.
Container, import					14,700			44,100	
FCL				2,035	11,800	24	2,035	23,500	48
LCL				3,010	2,900	9	3,010	5,900	18
EMPTY							1,310	14,700	19
Landing & Delivery				56.2/ton	250 x1,000tons	14	56.2/ton	500 x1,000tons	28
Container, export					14,700			44,100	
FCL				2,035	11,800	24	2,035	35,300	72
LCL				2,862	2,900	8	2,862	8,800	25
Shipping				19.8/ton	250 x1,000tons	5	19.8/ton	750 x1,000tons	15
Transhipment							2,320	7,400	17
Container, revenue Sub-Total			(0)			(84)			(242)
Grand Total			390			466			578

Table – V.7.7 Maintenance & Operation Costs in Percentage of Investment

Items	Percentages
Straddle carrier	10%
Cargo handling equipment other than straddle carrier	5%
Building, power, lighting, water supply	3%
Pavement, waterway, anchorage, roads in port	1%
Quaywall, Revetment	0.5%

Table – V.7.8 Condition for Case Study (Cases A, B_1 and B_2)

Case	Long-term Loan	Consolidated Fund	Tariff Rate
A	Interest rate: 8% Term: 20 years (including 5-years deferment)	No interest Term: 20 years (including 5-years deferment)	Current tariff
B_1	Same as above	Interest rate: 8% Term: 15 years (including 5-years deferment)	Raising current tariff except for container by 25% on and after 1981.
B_2	Same as above	Interest rate: 4% Term: 20 years (including 5-years deferment)	Same as above

Table – V.7.9 Condition for Case C

Case	Long-term Loan	Consolidated Fund	Tariff Rate
C	Interest rate: 3% Term: 30 years (including 10-years deferment)	Interest rate: 8% Term: 15 years (including 5-years deferment)	Raising current tariff except for container by 18% on and after 1981.

Table – V.7.10 Estimate on Revenue with 25% Raise of Current Tariff

	1978 Actual			1983			1984		
	Revenue per ton Rs./ton	Cargo Tonnage 1,000tons	Revenue Rs. M.	Revenue per ton Rs./ton	Cargo Tonnage 1,000tons	Revenue Rs. M.	Revenue per ton Rs./ton	Cargo Tonnage 1,000tons	Revenue Rs. M.
Port & Harbour Dues	(1) 7.8	2,945	23	(1.25) 9.75	3,313	32	(1.25) 9.75	3,450	34
Rents	(1) 9.8	2,945	29	(1.25) 12.25	3,313	41	(1.25) 12.25	3,450	42
Pilotages	(1) 1.3	2,945	4	(1.25) 1.63	3,313	5	(1.25) 1.63	3,450	6
Quay charges	(1) 1.5	2,945	4	(1.25) 1.88	3,313	6	(1.25) 1.88	3,450	6
Others			13			13			13
(CPC section Total)			(73)			(97)			(101)
Stevedoring	(1) 53.2	2,945	157	(1.25) 66.50	2,813	187	(1.25) 66.50	2,200	146
Landing & Delivery	(1) 56.2	1,895	106	(1.25) 70.25	1,658	116	(1.25) 70.25	1,510	106
Shipping	(1) 19.8	1,050	21	(1.25) 24.75	1,155	29	(1.25) 24.75	690	17
Transhipment			1			1			1
Supply of water	(1) 2.1	2,945	6	(1.25) 2.63	3,313	9	(1.25) 2.63	3,450	9
Others			8			8			8
(P(C)C section Total)			(299)			(350)			(287)
P T P S C	(1) 6.0	2,945	18	(1.25) 7.50	3,313	25	7.50	3,450	26
Sub-Total			(390)			(472)			(414)
				Revenue per TEU Rs./TEU	TEU	Revenue Rs. M.	Revenue per TEU Rs./TEU	TEU	Revenue Rs. M.
Container, import					14,700			44,100	
FCL				2,035	11,800	24	2,035	23,500	48
LCL				3,010	2,900	9	3,010	5,900	18
EMPTY							1,310	14,700	19
Landing & Delivery				(1.25) 70.25/ ton	250 x 1,000tons	18	(1.25) 70.25/ ton	500 x 1,000tons	35
Container, export					14,700			44,100	
FCL				2,035	11,800	24	2.0 2,035	35,300	72
LCL				2,862	2,900	8	2,862	8,800	25
Shipping				(1.25) 24.75/ ton	250 x 1,000tons	6	(1.25) 24.75/ ton	750 x 1,000tons	19
Transhipment							2,320	7,400	17
Container, revenue Sub-Total			(0)			(89)			(253)
Grand Total			390			561			667

Table – V.7.11 Statement of Revenue and Expenditure (Summary)

(Unit: Million Rs.)

	Case	1978 ~1980 (3 years)	1981	1982	1983	1984	1985	1986	1987	1988 ~1994 (7 years)	1995 ~2004 (10 years)
Revenue	A	1,208	419	466	466	578	581	588	592	4,144	5,920
	B_1	1,208	513	561	561	667	671	682	686	4,802	6,860
	B_2	1,208	513	561	561	667	671	682	686	4,802	6,860
	C	1,208	477	534	534	643	646	655	660	4,620	6,600
Expenditure	A	838	351	400	451	510	510	505	501	3,378	4,488
	B_1	838	355	408	467	531	531	525	518	3,442	4,498
	B_2	838	353	405	459	521	521	516	511	3,428	4,508
	C	838	343	385	432	488	488	487	485	3,324	4,563
Interest on loans	A	5	19	35	55	68	68	63	59	284	68
	B_1	5	22	42	70	88	88	82	75	341	68
	B_2	5	20	39	62	78	78	73	68	327	78
	C	2	10	20	36	46	46	44	42	223	133
Profit before Depreciation	A	370	68	66	15	68	71	83	91	766	1,432
	B_1	370	158	153	94	136	140	157	168	1,360	2,362
	B_2	370	160	156	102	146	150	166	175	1,374	2,352
	C	370	134	149	102	155	158	168	175	1,296	2,037
Depreciation		6	6	11	12	35	35	35	35	245	350
Profit after Depreciation	A	364	62	55	3	33	36	48	56	521	1,082
	B_1	364	152	142	82	101	105	122	133	1,115	2,012
	B_2	364	154	145	90	111	115	131	140	1,129	2,002
	C	364	128	138	90	120	123	133	140	1,051	1,687

Table – V.7.12 Statement of Source and Application of Funds (Summary)

(Unit: Million Rs.)

	Case	1980	1981	1982	1983	1984	1985	1986	1987	1988 ~1994 (7 years)	1995 ~2004 (10 years)
Source of Funds											
Profit before Depreciation	A	105	68	66	15	68	71	83	91	766	1,432
	B_1	105	158	153	94	136	140	157	168	1,360	2,362
	B_2	105	160	156	102	146	150	166	175	1,374	2,352
	C	105	134	149	102	155	158	168	175	1,296	2,037
Long-term Loans		128	223	179	314	–	–	–	–	–	–
Consolidated Fund		3	59	55	140	–	–	–	–	–	–
Application of Funds											
Cost of Fixed Assets Addition		131	282	234	454	–	–	–	–	–	–
Repayment Amount	A	–	–	–	–	–	73	73	73	513	369
	B_1	–	–	–	–	–	82	82	82	572	283
	B_2	–	–	–	–	–	73	73	73	513	369
	C	–	–	–	–	–	26	26	26	390	422
Income Tax	A	52	31	28	2	17	18	24	28	262	542
	B_1	52	76	71	41	51	53	61	67	558	1,006
	B_2	52	77	73	45	56	58	66	70	565	1,001
	C	52	64	69	45	60	62	67	70	526	844
Divident		53	53	53	53	53	53	53	53	371	530
Increase/Decrease of Net Current Assets	A	0	-16	-15	-40	- 2	-73	-67	-63	- 380	- 9
	B_1	0	29	29	0	32	-48	-39	-34	- 141	543
	B_2	0	30	30	4	37	-34	-26	-21	- 75	452
	C	0	17	27	4	42	17	22	26	9	241

Table – V.7.13 Balance Sheet (Summary)

(Unit: Million Rs.)

	Case	1978	1981	1982	1983	1984	1985	1986	1987	1994	2004
Assets											
Fixed Assets		1,296	1,703	1,926	2,368	2,333	2,298	2,263	2,228	1,983	1,633
Net Current Assets	A	192	307	292	252	250	177	110	47	-333	-342
	B_1	192	352	381	381	413	365	326	292	151	694
	B_2	192	353	383	387	424	390	364	343	268	720
	C	192	340	367	371	413	430	452	478	487	728
Capital Employed											
Capital Loan by Government		1,332	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336
Long-term Loans	A	–	351	530	844	844	788	732	676	283	–
	B_1	–	351	530	844	844	788	732	676	283	–
	B_2	–	351	530	844	844	788	732	676	283	–
	C	–	351	530	844	844	844	844	844	633	211
Consolidated Fund	A	–	62	117	257	257	240	223	206	86	–
	B_1	–	62	117	257	257	231	205	179	–	–
	B_2	–	62	117	257	257	240	223	206	86	–
	C	–	62	117	257	257	231	205	179	–	–
Other Reserve and Provision	A	156	261	235	183	146	111	82	57	- 55	- 45
	B_1	156	306	324	312	309	308	316	329	515	991
	B_2	156	307	326	318	320	324	336	353	546	1,017
	C	156	294	310	302	309	317	330	347	501	814
Total	A	1,488	2,010	2,218	2,620	2,583	2,475	2,373	2,275	1,650	1,291
	B_1	1,488	2,055	2,307	2,749	2,746	2,663	2,589	2,520	2,134	2,327
	B_2	1,488	2,056	2,309	2,755	2,757	2,688	2,627	2,571	2,251	2,353
	C	1,488	2,043	2,293	2,739	2,746	2,728	2,715	2,706	2,470	2,361

Table – V.7.14 Operating Ratio and Return on Net Fixed Assets

	Case	1983	1984	1988	1994	2004
Operating Ratio	A	99.4%	94.3%	89.7%	85.1%	80.6%
	B_1	85.4	84.9	79.6	73.9	69.7
	B_2	84.0	83.4	78.7	74.2	69.7
	C	83.1	79.8	78.5	75.8	73.6
Return on Net Fixed Assets	A	2.4%	4.3%	5.2%	5.8%	7.0%
	B_1	6.4	8.1	9.5	10.5	12.7
	B_2	6.4	8.1	9.5	10.5	12.7
	C	5.3	7.1	8.3	9.2	11.1

Note: 1. operating ratio : $\frac{\text{operating expenditure}}{\text{operating revenue}} \times 100$

2. Return on net fixed assets :

$$\frac{\text{Profit after depreciation and before interest}}{\text{net fixed assets at end of year}} \times 100$$

Table – V.7.15 Financial Rate of Return (Case B₁)

(Unit: Million Rs.)

		Project Cost	Net Surplus Revenue	Present Value Discounted at 8% Project Cost	Present Value Discounted at 8% Net Surplus Revenue
-9	up to 1971	9		18	
-8	1972	1		2	
-7	1973	2		3	
-6	1974	2		3	
-5	1975	30 { 2		3	
-4	1976	3		4	
-3	1977	4		5	
-2	1978	3		3	
-1	1979	4		4	
0	1980	131		131	
1	1981	282	46	261	43
2	1982	234	61	201	52
3	1983	454	30	360	24
4	1984		90		66
5	1985		94		64
6	1986		105		66
7	1987		109		64
8	1988		↓		59
9	1989				55
10	1990				50
11	1991				47
12	1992				43
13	1993				40
14	1994				37
15	1995				34
16	1996				32
17	1997				29
18	1998				27
19	1999				25
20	2000				23
21	2001				22
22	2002				20
23	2003		↓		19
24	2004		109		17
Residual Value			373		59
Total		1,131	2,761	998	1,017

FRR = 8.22%

Table – V.7.16 Relation between Tariff Raise and FRR

Percentage of tariff raise	FRR
10%	1.87%
18%	5.08%
25%	8.22%
30%	10.47%

Table – V.7.17 Long-term Loan Schedule

(Unit: Million Rs.)

	Invest-ment	Long-term loan	Con-solidate fund	Case A			Case B_1			Case B_2			Case C		
				Repay-ment amount	Interest	Balance at end	Repay-ment amount	Interest	Balance at end	Repay-ment amount	Interest	Balance at end	Repay-ment amount	Interest	Balance at end
1980	131	128	3	–	5	131	–	5	131	–	5	131	–	2	131
1981	282	223	59	–	19	413	–	22	413	–	20	413	–	10	413
1982	234	179	55	–	35	647	–	42	647	–	39	647	–	20	647
1983	454	314	140	–	55	1,101	–	70	1,101	–	62	1,101	–	36	1,101
1984	–	–	–	–	68	1,101	–	88	1,101	–	78	1,101	–	46	1,101
1985	–	–	–	73	68	1,028	82	88	1,019	73	78	1,028	26	46	1,075
1986	–	–	–	73	63	955	82	82	937	73	73	955	26	44	1,049
1987	–	–	–	73	59	882	82	75	855	73	68	882	26	42	1,023
1988	–	–	–	73	54	809	82	68	773	73	62	809	26	40	997
1989	–	–	–	73	50	736	82	62	691	73	57	736	26	38	971
1990 ~1994	–	–	–	367	180	369	408	211	283	367	208	369	338	145	633
1995 ~1999	–	–	–	369	68	–	283	68	–	369	78	–	211	82	422
2000 ~2004	–	–	–	–	–	–	–	–	–	–	–	–	211	51	211

Table – V.7.18 Statement of Revenue and Expenditure (Case B_1)

(Unit: Million Rs.)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990 ~1994 5 years	1995 ~1999 5 years	2000 ~2004 5 years
Revenue															
CPC section	73	76	76	93	97	97	101	104	106	108	108	108	540	540	540
P(C)C section	299	314	290	370	350	350	287	283	284	284	284	284	1,420	1,420	1,420
PTPSC section	18	19	18	24	25	25	26	26	28	28	28	28	140	140	140
Container section	–	–	25	26	89	89	253	258	264	266	266	266	1,330	1,330	1,330
Total	390	409	409	513	561	561	667	671	682	686	686	686	3,430	3,430	3,430
Expenditure															
Personnel Cost	204	224	246	271	298	328	361	361	361	361	361	361	1,805	1,805	1,805
Operation and Maintenance Cost	32	33	32	38	42	42	53	53	53	53	53	53	265	265	265
Administration Cost	10	11	10	11	11	11	12	12	12	12	12	12	60	60	60
B.T.T	4	4	4	5	6	6	7	7	7	7	7	7	35	35	35
Interest on Loans	–	–	5	22	42	70	88	88	82	75	68	62	211	68	–
Others	6	6	7	8	9	10	10	10	10	10	10	10	50	50	50
Total	256	278	304	355	408	467	531	531	525	518	511	505	2,426	2,283	2,215
Profit before Depreciation	134	131	105	158	153	94	136	140	157	168	175	181	1,004	1,147	1,215
Less Depreciation	2	2	2	6	11	12	35	35	35	35	35	35	175	175	175
Profit after Depreciation	132	129	103	152	142	82	101	105	122	133	140	146	829	972	1,040
Income Tax	–	–	52	76	71	41	51	53	61	67	70	73	415	486	520
Profit after Income Tax	132	129	51	76	71	41	50	52	61	66	70	73	414	486	520
Devident	–	–	53	53	53	53	53	53	53	53	53	53	265	265	265
Net Profit to Port	132	129	– 2	23	18	–12	– 3	– 1	8	13	17	20	149	221	255
Accumulated Net Profit from 1978	156	285	283	306	324	312	309	308	316	329	346	366	515	736	991

Table – V.7.19 Statement of Source and Application of Funds (Case B_1)

(Unit: Million Rs.)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990 ~1994 5 years	1995 ~1999 5 years	2000 ~2004 5 years
Source of Funds															
Profit before Depreciation		131	105	158	153	94	136	140	157	168	175	181	1,004	1,147	1,215
Long-term Loans			128	223	179	314	–	–	–	–	–	–	–	–	–
Consolidated Fund			3	59	55	140	–	–	–	–	–	–	–	–	–
Others		4	–	–	–	–	–	–	–	–	–	–	–	–	–
Total		135	236	440	387	548	136	140	157	168	175	181	1,004	1,147	1,215
Application of Funds															
Cost of Fixed Assets Addition		4	131	282	234	454	–	–	–	–	–	–	–	–	–
Repayment of Long-term Loans		–	–	–	–	–	–	56	56	56	56	56	281	283	–
Repayment to Consolidated Fund		–	–	–	–	–	–	26	26	26	26	26	127	–	–
Income Tax		–	52	76	71	41	51	53	61	67	70	73	415	486	520
Divident		–	53	53	53	53	53	53	53	53	53	53	265	265	265
Total		4	236	411	358	548	104	188	196	202	205	208	1,088	1,034	785
Increase/Decrease (–) of Net Current Assets		131	0	29	29	0	32	–48	–39	–34	–30	–27	–84	113	430
Net Current Assets at Biginning of Year		192	323	323	352	381	381	413	365	326	292	262	235	151	264
Net Current Assets at End of Year	192	323	323	352	381	381	413	365	326	292	262	235	151	264	694

Table – V.7.20 Balance Sheet (Case B_1)

(Unit: Million Rs.)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1994	1999	2004
Assets															
Fixed Assets	1,296	1,298	1,427	1,703	1,926	2,368	2,333	2,298	2,263	2,228	2,193	2,158	1,983	1,808	1,633
(Land)	(1,250)	(1,250)	(1,250)	(1,250)	(1,250)	(1,393)	(1,393)	(1,393)	(1,393)	(1,393)	(1,393)	(1,393)	(1,393)	(1,393)	(1,393)
(Net Fixed Assets to be depreciated)	(20)	(18)	(134)	(271)	(289)	(975)	(940)	(905)	(870)	(835)	(800)	(765)	(590)	(415)	(240)
(Construction in process a/c)	(26)	(30)	(43)	(182)	(387)	(–)	(–)	(–)	(–)	(–)	(–)	(–)	(–)	(–)	(–)
Net Current Assets	192	323	323	352	381	381	413	365	326	292	262	235	151	264	694
Total	1,488	1,621	1,750	2,055	2,307	2,749	2,746	2,663	2,589	2,520	2,455	2,393	2,134	2,072	2,327
Capital Employed															
Capital Loan by Government	1,332	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336
Long-term Loan	–	–	128	351	530	844	844	788	732	676	620	564	283	–	–
Consolidated Fund			3	62	117	257	257	231	205	179	153	127	–	–	–
Other Reserves and Provision	156	285	283	306	324	312	309	308	316	329	346	366	515	736	991
Total	1,488	1,621	1,750	2,055	2,307	2,749	2,746	2,663	2,589	2,520	2,455	2,393	2,134	2,072	2,327