shown in Figures 5.4 and 5. The number of freight trains in 2000 is estimated at nine trains and seven trains for the sections of Surat Thani-Phangnga and Phangnga-Phuket, respectively. The number of passenger trains in 2000 is estimated at three trains and two trains for the respective sections, too.

The number of freight trains was estimated based on the following formula :

$NF = QF \times (1 + F)) / A$

where NF : Number of freight trains per day for one way
QF : Freight traffic volume in tons per day for one way
F : Seasonal fluctuation in traffic volume (30%)
A : Average net ton-km per train-km (tons per train: 428 tons)

The number of passenger trains was estimated based on the following formula :

$NP = (QP \times (1 + S)) / (SC \times L \times N)$

where NP : Number of passenger trains per day for one way
QP : Passenger traffic volume in persons per day for one way
S : Seasonal fluctuation in traffic volume (20%)
SC : Seating capacity of a passenger car (76 persons)
L : Loading factor (80%)
N : Average number of passenger cars per train (11 cars)

5.2.2 Roles and Functions of East-West Link

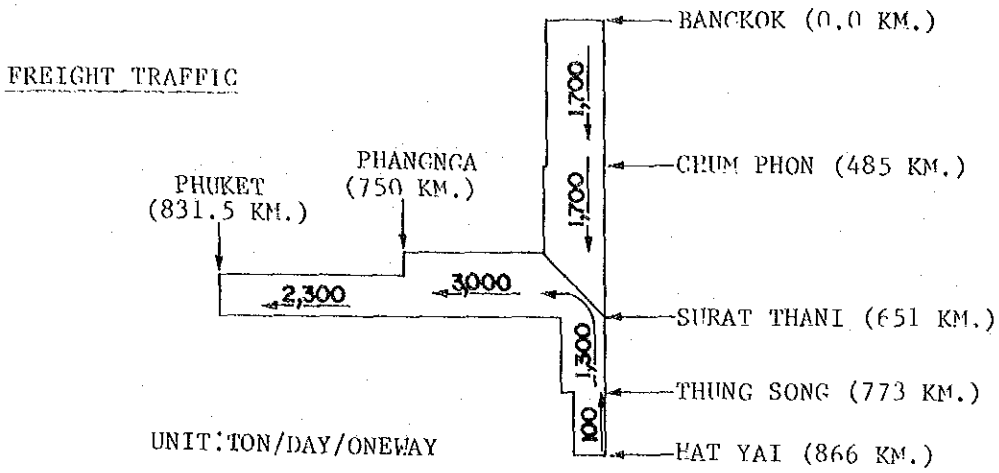
1) East-West Link at the End of the Fifth Five Year Plan Period

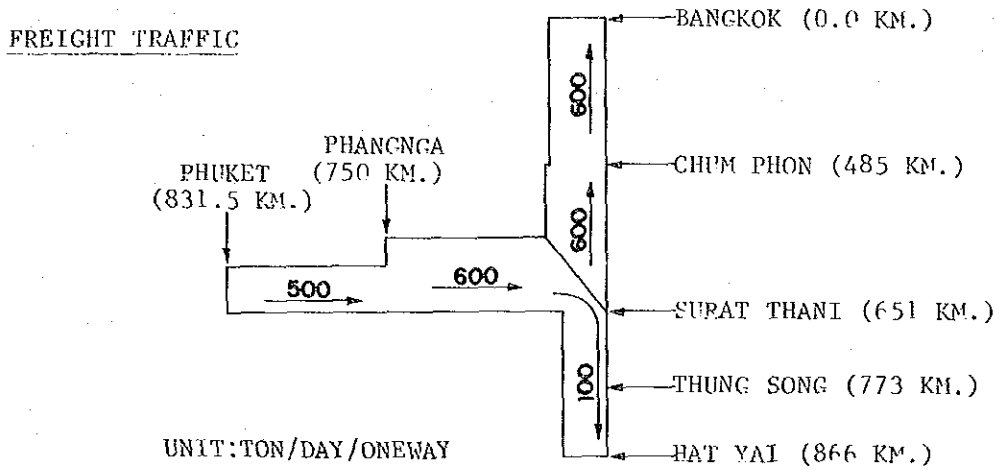
The length of the existing paved link connecting Phuket with Surat Thani is about 280 kilometers via Takua Pa, the junction of Route 4 and Route 401. This link contains very steep mountainous area between Takua Pa and Phanom, which places a heavy burden for trucks to negotiate. However, the distance will be reduced to about 240 kilometers due to the scheduled pavement of Route 4040 connecting Thap Put on Route 4 with Phanom on Route 401. The pavement of this section will have a large effect to reduce the traveling time between Phuket and Surat Thani.

The scheduled improvement plan for the road section between Surat Thani and Phuket is as follows :

Surat Thani-Phun Phin (Route 41)

New road construction is planned by DOH to ease the traffic congestion between Surat Thani and Phun Phin because the program to widen the existing road to dual





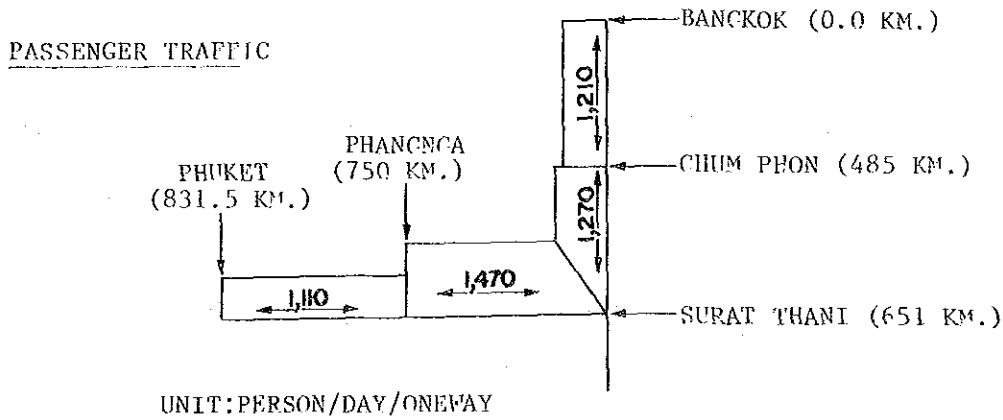


Fig. 5.3 TRAFFIC DEMAND ON EAST-WEST RAIL LINK IN 2000

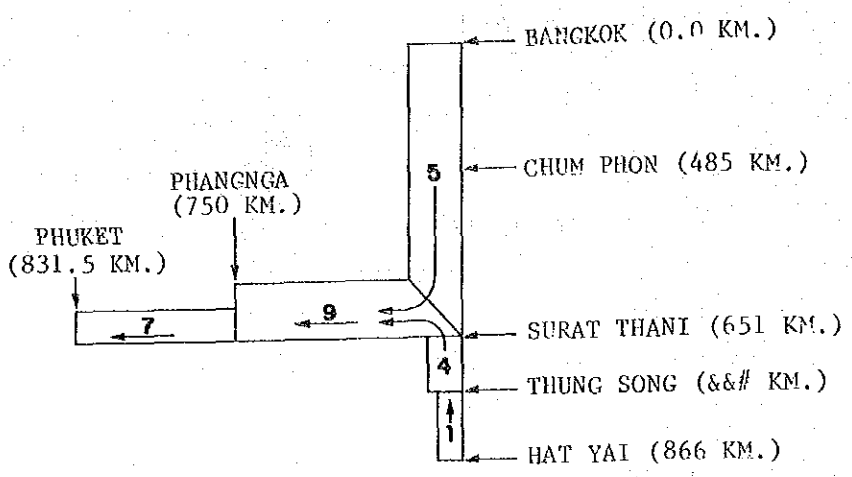


Fig. 5.4 REQUIRED NUMBER OF FREIGHT TRAINS IN 2000

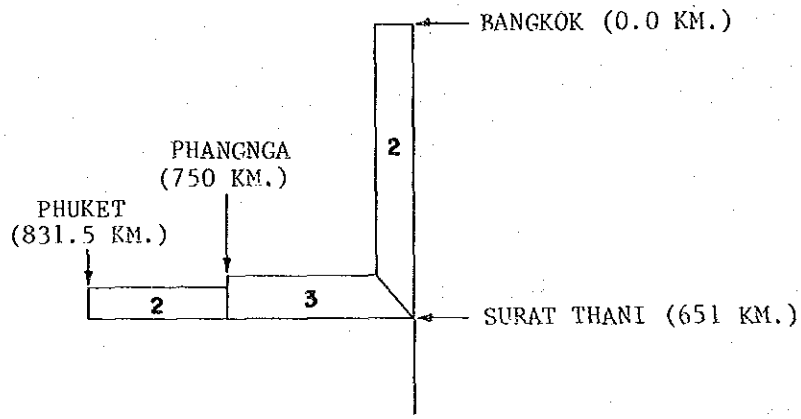


Fig. 5.5 REQUIRED NUMBER OF PASSENGER TRAINS IN 2000

carriage way is confronted with a land acquisition problem.

Route 41 - Phanom

This section involves steep mountainous area between Khiri Rattha- nikhom and Phanom. The highway standard is equivalent to S3 Standard on account of steep gradient and short radius of curve. Some kind of study to improve this section is going to be performed in the next Five-Year Plan period.

Phanom - Thap Put

Pavement of Provincial Highway Route 4040 which is partially asphalted now will be completed throughout the whole stretch during the Fifth Five-Year Plan period. Though the terrain is rolling and hilly, horizontal and vertical alignment of the highway is fairly good.

Thap Put -Phangnga

The existing National Highway Route 4 winds a way through Nang Hong Mountain with steep gradient. In order to detour the mountain and curtail the distance, a new bypass is going to be constructed in flat area by improving the existing Provincial Road Routes 4152 and 4144 and constructing a new link of two kilometer length in-between during the Fifth Five Year Plan period.

Phangnga - Khok Kloi

The National Highway Route 4 was upgraded to the standard.

Khok Kloi - Phuket Island

15 years have passed since the completion of the existing Sarasin Bridge, which suffers such damages as stripping of concrete, rust of reinforcing bar and defects of expansion point. Special maintenance work is to be performed to repair the damages.

Highways on Phuket Island

The National Highway Route 402 is now being upgraded from S4 Standard (runway width of 5.5 meters) to S1 Standard (seven meters). Phuket Bypass of eight kilometers to detour the urban area is now under construction. Upgrading of the Provincial Highway Route 4023 has almost been completed to provide better access to Phuket Deep Seaport. The connecting link of two kilometer length between Phuket Bypass and Route 4023 is expected to be constructed in the next Five- Year Plan period.

Through these improvement, a prototype East-West Link will come into existence to connect Phuket with Surat Thani in reduced travelling time.

2) Roles and Functions Required

Roles and functions required for the development of East-West Link can be articulated as follows :

- To improve and develop the transportation network in the hinterland of Phuket Deep Seaport, especially from the viewpoint of heavy vehicle traffic, so as to retrench the inland transportation cost to the port.

- To provide better and efficient transportation network between Surat Thani and Phuket for attaining interactive economic development of the two growth poles and the area inbetween.

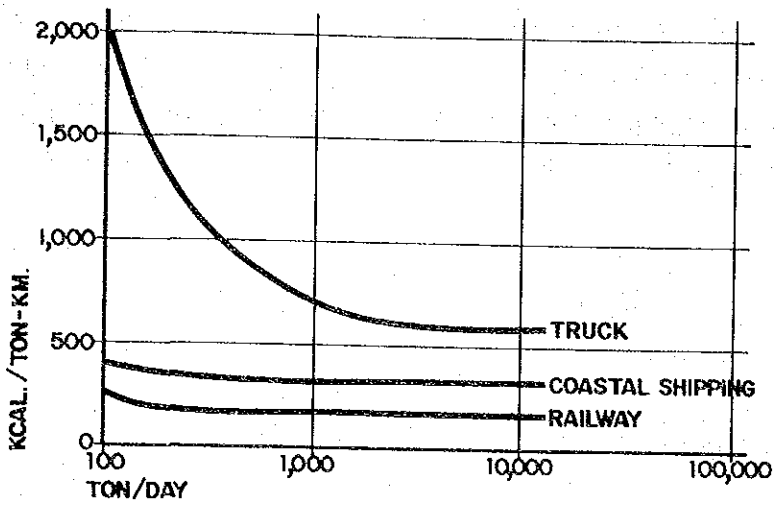
- To facilitate cargo transportation from Bangkok and other regions to Phuket Deep Seaport which is an alternate gateway to the western situated countries to Bangkok/Laem Chabang Ports.

- To provide energy saving transportation means between Bangkok and provinces on the Andaman Sea Coast to cope with the increasing transportation demand of both cargo and passenger.

- To provide additional capacity to the existing and programmed transportation network between Surat Thani and Phuket to cope with the future increase of traffic demand.

As presented in Table 5.4, transportation demand in 2000 consists of various combination of origin and destination pairs. The transpor- tation demand to be completed in the Upper South is estimated at about 50 percent for cargo transportation and 85 percent for passenger transportation. In consideration of the inter provincial distance of 140 kilometers for Surat Thani-Phangnga, 230 kilometers for Surat Thani-Phuket and 80 kilometers for Phangnga-Phuket, most of the traffic in the Upper South will depend on road. On the other hand, the transportation demand related to Bangkok Metropolis and other regions will be shared by road and railway, with some inclination to railway, taking account of the distance of 750 kilometers for Phangnga-Bangkok and 830 kilometers for Phuket- Bangkok. Ship cannot be an alternative means between Phangnga/Phuket and Bangkok/other regions because of the long roundabout of Malay Peninsula. Air transport is additional means for passenger transportation. Figure 5.6 illustrates the energy efficiency comparison among three transportation means at the distance of 600 kilometers. Energy efficiency of railway

remains at about 200 kilocalories per ton-kilometer without particular relationship to traffic volume, while energy efficiency of trucks increases to a great extent in proportion to traffic volume. Energy efficiency of railway is higher than that of trucks by three to four times.



SOURCE. "ADVANCED TRANSPORTATION PLANNING"
BY Dr.M. SUGAWARA. P.206

Fig. 5.6 ENERGY EFFICIENCY COMPARISON AMONG TRANSPORTATION MODES

Taking the above into consideration, major roles and functions of railway link and road link can be identified as follows :

Railway Link

- To take a major part in long haul transportation for cargo and passenger. To be more specific, railway link will carry cargoes for export to the western situated countries from Bangkok and other regions to Phuket Deep Seaport, transport primary and manufactured products from the Upper South to Bangkok and consumer and industrial goods from Bangkok to the Upper South, and transport passengers to and from Bangkok.

- To reduce the number of heavy vehicles mainly engaged in long haul transportation through the function mentioned above. This will ease the heavy vehicle traffic on road link and possibly reduce the maintenance cost of road which is incurred mostly by the damages caused by heavy vehicles.

Road Link

- To take a major part in transporting cargo and passenger of which trips are to be completed in the Upper South. To be more specific, East-West Road Link will contribute to enlarging the hinterland of Phuket Deep Seaport and to reducing the travelling time between Phuket and Surat Thani.

- To provide additional capacity to the prototype East-West Road Link through either developing/upgrading some part of the link or widening two-lane road to four-lane road for the whole link to cope with the estimated future increase of transportation demand.

5.2.3 Development of East-West Road Link

1) Principles of Design

Based on the considerations described in the preceding section, special attention was paid to the following points :

- To make full use of the existing and programmed highways for the establishment of East-West Road Link.

- To strength the pavement, where necessary, to the extent that heavy vehicles can associate with less damage to the road.

- To provide sufficient width of carriage way, where necessary, to accommodate the expected future increase of traffic.

- To avoid the conflict between local and long distance traffic as much as possible.

- To develop new road links, if necessary, in case that improvement will incur as much investment cost as new construction, and that relocation of the route will have greater effect on developing the area along the route.

- To contrive to minimize the construction cost.

Minimum design standard for primary national highway specified by DOH was applied for designing East-West Link, as shown in Table 5.6, taking account of the roles and functions required.

2) Geometric Design of Alignment

Prior to the study on route alignment, data and information were collected through interviews to DOH and site reconnaissance by land and air. Data and information consist of conditions of the existing roads and bridges, terrain, soil type including CBR value, flood level in the past, construction materials and so forth. Engineering studies were carried out on topo-maps mainly in the scale of 1:50,000 and supplementarily on aerophotos in the scale of 1:15,000.

Geometric design of alignment is as shown in Figure 5.7(1) where total length of East-West Road Link reaches 224 kilomcters. The followings are the brief description of some important sections :

New Construction (88.3 kilometers)

Surat Thani - Route 41 (17.9 kilometers)

The existing road of this section is below the required standard in terms of horizontal and vertical alignments. Construction of a short cut route traversing the swampy area is very costly because of the piles necessary to support the foundation. A new alignment is proposed from Surat Thani Bypass to Airport, passing north of Phun Phin. This new route will improve accessibility to the airport and the new industrial estate proposed by our study.

Route 41 - Phanom (46.9 kilometers)

The existing route 401 passes through steep mountainous area between Khiri Ratthanikhom and Phanom. Improvement of this section necessitates large quantity of cut and fill for vertical betterment and some tunnels for horizontal betterment. However, improvement of this section will have little development effect on the area in spite of the large investment cost to be incurred. A new alignment is proposed along the railway line, north of Khiri Rattanikhom Mountains. Terrain of this side is flat plain where agricultural development is in progress. This new route is expected to give development impact on this area and easy access to agricultural processing factories in the new industrial estate proposed.

Thap Put -Phangnga Bypass (8.3 kilometers)

This route is proposed only for reducing the distance between Thap Put and

Table 5.6 GEOMETRIC DESIGN STANDARD

Terrain Classification		Improvement of Existing Road		Development of New Road
		Flat & Rolling	Hilly & Mountainous	Flat & Rolling
Design Speed	Km/h	80	70	80
Minimum Radius	m	260	200	300
Maximum Gradient	%	4	5	4
Stopping Sight Distance	m	115	90	115
Width of Pavement	m	7.00	7.00	7.00
Width of Outer Shoulder *1	m	2.50	2.50	2.50
Max. Superelevation	%	10	10	10
Type of Surfacing		Asphalt Concrete (Hot Mix.)		
Bridge Width (Between Curbs)	m	9.00	9.00	9.00
Right of Way	m	40 - 60	40 - 60	40 - 80

Source: DOH

Note: *1 This can be reduced according to the condition of existing roads.

Phangnga Bypass without passing Route 4.

Phuket New Bridge (15.2 kilometers inclusive of access road on both sides)

This alignment forms almost a straight line from Route 4 on main land to Route 402 on Phuket Island with the shortest distance. There are three main grounds to support this new route :

- The existing Sarasin Bridge will need reconstruction at least in 15 years to cope with the expected heavy traffic even if some special maintenance works are carried out.

- This new bridge will reduce the distance of this section from 26 to 15 kilometers. This short cut will further promote the interrelated development of Phuket and Phangnga.

- This new route will bypass Khok Kloi commercial area where local and long distance traffics will create conflicts.

The length of the new bridge is 800 meters and planned to be a symbol of Phuket tourism development zone.

Partial Improvement (135.7 kilometers)

Improvement planned on the remaining sections other than the new construction sections are mainly composed of strengthening the pavement and widening the carriage way. Some part of Route 4040 connecting Phanom with Thap Put needs vertical and horizontal realignment to be upgraded to the primary highway standard. Construction of bypass will become necessary at such village centers as Thalang and Muang Mai along the Route 402 in Phuket Island.

3) Geometric Design of Cross Section

The typical cross sections adopted for this study are as shown in Figures 5.8 through 5.10. Figure 5.8 shows the typical cross section for two lanes. Figures 5.9 and 5.10 show the typical cross sections for four lanes, the former indicating dual carriage way for the new construction section, the latter indicating widening two lanes to four lanes for the maximum use of the existing two lanes.

4) Pavement Structure

Pavement structure for the purpose of cost estimation is as shown in Table 5.7 based on AASHTO Interim Guide for Design of Pavement Structure, 1972.

Table 5.7 PAVEMENT STRUCTURE

	Thickness	Structural Layer Coefficient	Structural Number
Asphaltic Concrete Surfacing	7.5 cm	0.44	1.30
Crushed Stone Base	30 cm	0.14	1.70
Soil Aggregate Subbase	20 cm	0.11	0.90
Improved Subgrade	15 cm	0.10	0.59
Total	72.5 cm		4.49

Source: The Team based on AASHTO

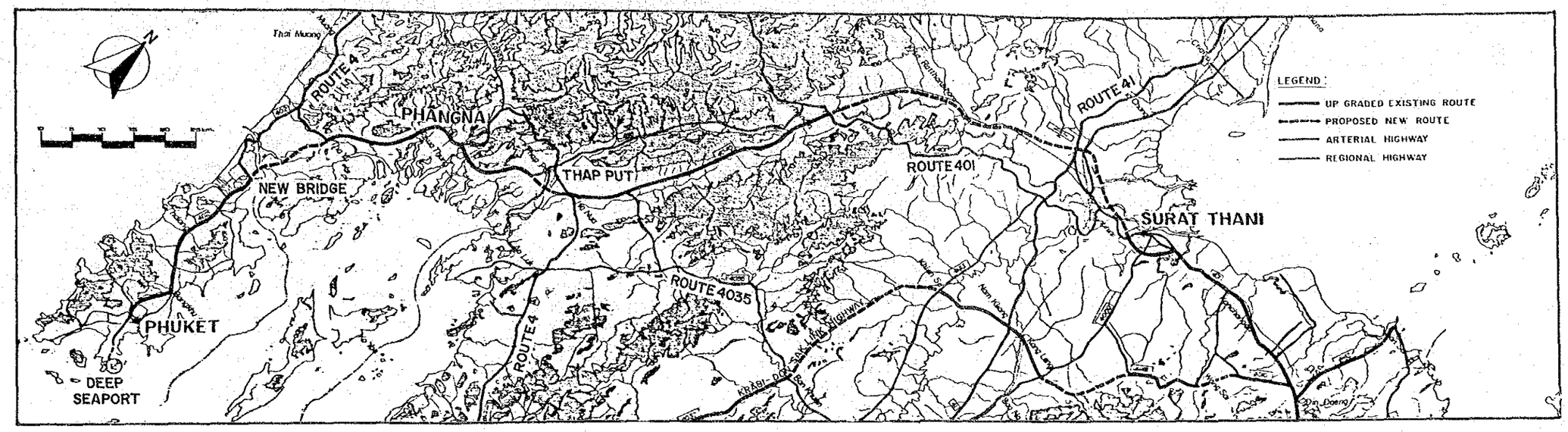


Fig. 5.7(1) EAST-WEST ROAD LINK

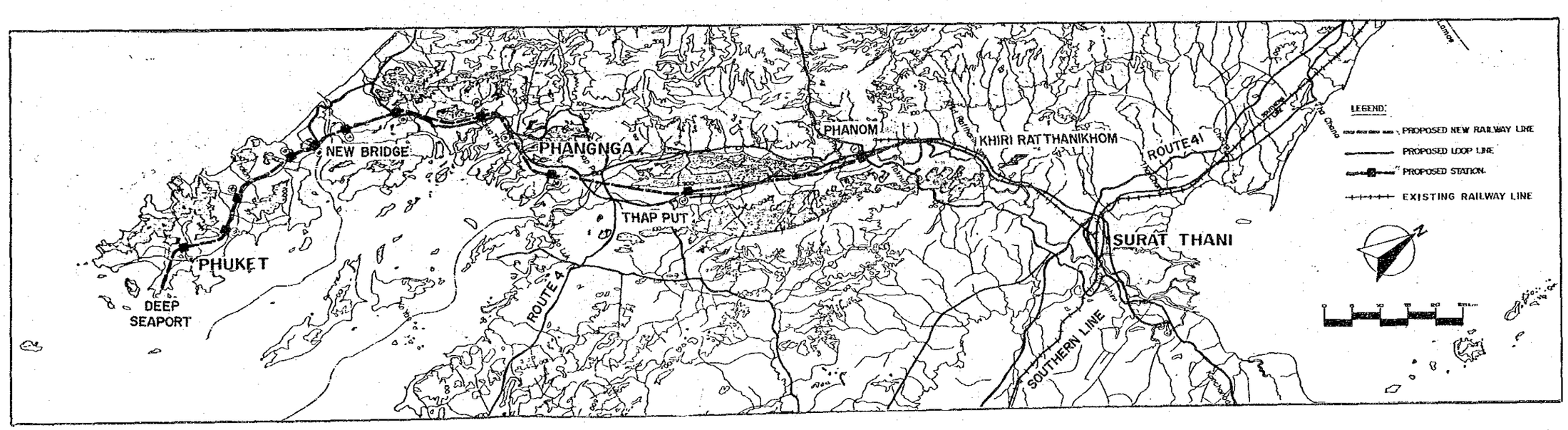


Fig. 5.7(2) EAST-WEST RAIL LINK

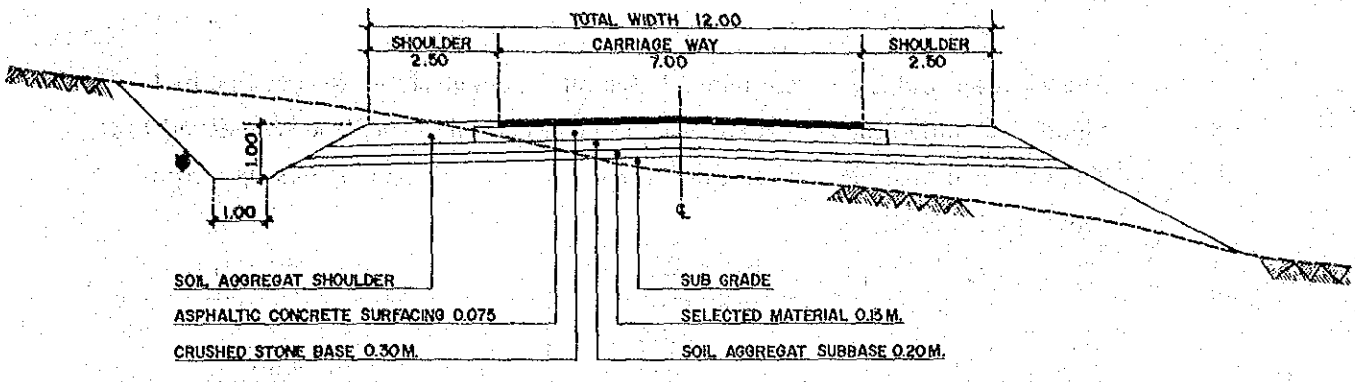


Fig. 5.8 TYPICAL CROSS SECTION FOR TWO LANE ROAD

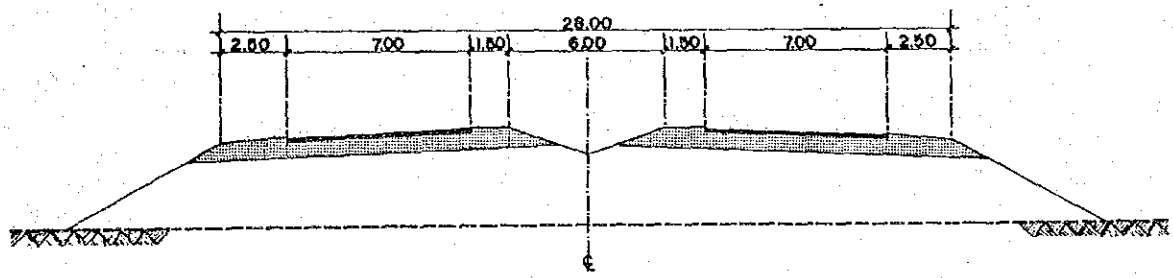


Fig. 5.9 TYPICAL CROSS SECTION FOR FOUR LANE ROAD
(NEW CONSTRUCTION)

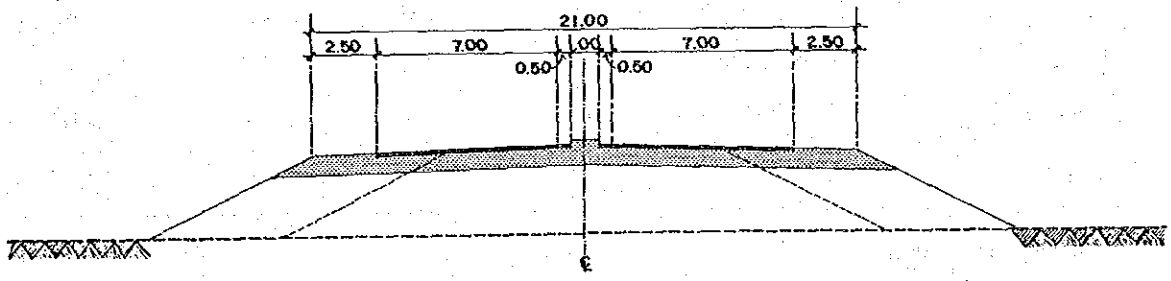


Fig. 5.10 TYPICAL CROSS SECTION FOR FOUR LANE ROAD
(WIDENING)

5) Bridge

The width of bridge was determined based on the design standard specified by DOH. Figure 5.11 shows the typical cross-section of the bridges for East-West Road Link. The type of bridge was classified into three categories for cost estimating purpose, as shown in Table 5.8.

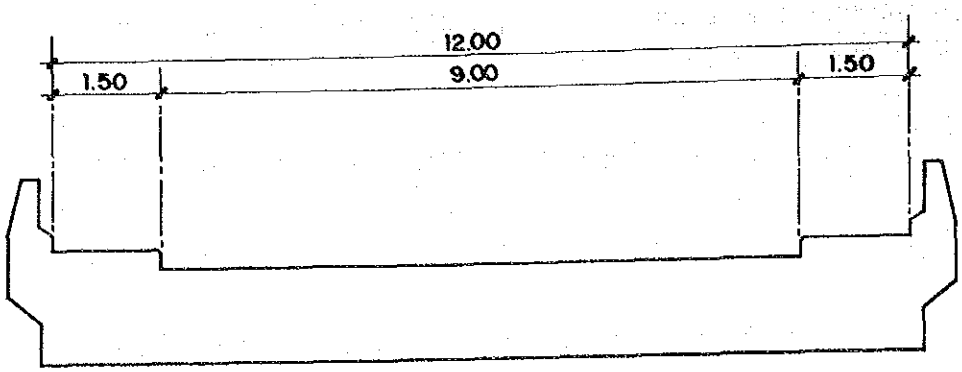


Fig. 5.11 TYPICAL CROSS-SECTION OF BRIDGES

Table 5.8 QUANTITY OF BRIDGES

Bridge	Length (m)	For 2 Lanes		For 4 Lanes	
		Q'ty	Length	Q'ty	Length
Medium	20 - 60	15	580 m	59	2,200 m
Long	80 - 100	7	660	20	1,800
Special	800	1	800	1	800
Total		23	2,040	80	4,800

Source: The Team

6) Estimation of Quantity and Cost

Based on the engineering studies described in the above, the estimated quantities were then converted to monetary terms by referring to the typical unit prices for each kind of work. The unit price applied to this study is shown in Table 5.9.

Table 5.9 UNIT PRICE LIST

Description	Unit	Engineer's Prices (1983) (Baht) North 1208	NE 2086/2	Central 3011/1	South Rt4/1 1/	Typical Feasibility Price E-1 Rt. 633
General & Earthworks						
Clearing & Grubbing	m^3	1.12	1.12	1.36	1.04	0.90
Roadway Exc. - Earth	m^3	21.50	18.25	15	24.70	18
Roadway Exc. - Soft Rock	m^3	60			60.76	
Roadway Exc. - Hard Rock	m^3	94				
Soft Spot Exc.& Replacement	m^3	-	61	94	124.45	62
Embankment		33.6	37	35	39.48	37
Selected Material(Type A)	m^3	62		79	68.69	71
Selected Material(Type B)	m^3	50	54	71	56.25	48
Removal of Bridge	lm					
Pavement						
Subbase	m^3	111.4	124	83	68.69	80
Aggregate Base	m^3	322	443	368	325.70	468
Shoulder	m^3	116	137	100		100
Shoulder(Two layer course)	m^3				214.16	
Surfacing						
Asphaltic Prime Coat	m^3	12	11.75	11	11.88	12
Asphaltic Tack Coat	m^3				6.95	
Single Bituminous Surface	m^3	24	27.5	28	21.23	27
Double Bituminous Surface	m^3	37.5	45	45.5		45
Asphalt Additive	l					110
Asphaltic Concrete	t				726	742
Concrete Structures						
Bridge Sta.	lm	36,905				35,000
Bridge Sta.	lm					
Bridge Sta.	lm					
Bridge Sta.	lm					
Bridge Total Length	lm					
Box Culv., Sta.	lm	17,890				
Box Culv., Sta.	lm		38,315			
Box Culv., Sta.	lm			28,000		
Box Culv., Sta.	lm					
Box Culv., All Sizes	lm					
R.C. Pipe Culvert - Ø 40	lm					675
R.C. Pipe Culvert - Ø 60	lm	770	875	650	970	904
R.C. Pipe Culvert - Ø 80	lm	1,080	1,320	1,000	1,319	1,364
R.C. Pipe Culvert - Ø 100	lm	1,540	1,675	1,400	1,914	1,814
R.C. Pipe Culvert - Ø 120	lm	2,135	2,130			2,110

1/ Unit price for South applied to this study

Source : DOH

The estimated costs for two lane and four lane highways are as shown in Table 5.10. The total cost for two lane highway is estimated at 1,382 million baht, while that for four lane highway is estimated at 3,007 million baht. For two lane highway, Phuket New Bridge is designed for accommodating both road and railway. 66 percent of the cost of Phuket New Bridge is allocated to road in accordance with the square meters that road occupies. The largest cost item is the bridge cost at the composition ratio of 21 percent, followed by pavement cost at 14 percent. For four lane highway, the cost of Phuket New Bridge is entirely allocated to road because the timing that necessitates both four lane highway and railway will be beyond the year 2000. The largest cost item is pavement cost at the composition ratio of 25 percent, followed by the bridge cost at 17 percent.

5.2.4 Development of East-West Rail Link

1) Existing Situations and Future Improvement

Total route kilometers and track length of railway network of the country in 1983 amounts to 3,735 kilometers mostly with single track. The Southern Line reaches 990 kilometers at Padang Besar and 1,159 kilometers at Sungai Kolok, and has four spur lines; Surat Thani- Khiri Ratthanikhom, Thung Song-Kantang, Khao Chum Thong-Nakhon Si Thammarat and Hat Yai-Songkhla. Rolling stock distribution depots are located at Chumphon, Thung Song and Hat Yai in the South.

According to the train operation schedule, trains daily operated between Bangkok and Surat Thani/further south consist of two express trains, four rapid trains and seven freight trains for each direction. It takes 12 hours and 15 minutes between Bangkok and Surat Thani by express train, the average operating speed being 53 kilometers per hour. Three mixed trains are daily operated on Khiri Ratthanikhom Spur Line.

Freight carried by the Southern Line showed an increasing trend from 752,100 tons in 1972 to 1,272,600 tons in 1982 at an annual growth rate of 5.4 percent. Main commodities carried by railway were cement, gypsum, construction materials, rice and miscellaneous products. Most of cement was despatched from Thi Wang Station near Thung Song to Hat Yai, Surat Thani, Chumphon and Thon Buri. Freight carried by Khiri Ratthanikhom Spur Line amounted to 30,100 tons in 1982.

Passengers carried by the Southern Line also showed an increasing trend from 17.5 million persons in 1972 to 21.5 million persons in 1982 at an annual growth rate of 2.1

Table 5.10 CONSTRUCTION COST OF EAST-WEST ROAD LINK

at 1983 price

Item	Unit	Unit Price(฿)	for 2 Lanes Q'ty(1000)	for 2 Lanes Cost(1000฿)	for 4 Lanes Q'ty(1000)	for 4 Lanes
Clearing & Grubbing	m^2	1	2,742.7	2,742	5,525.2	5,525
Road Way Excavation	m^3	25	545.0	13,625	1,741.0	43,525
Embankment	m^3	40	2,918.7	116,748	7,977.7	319,109
Selected Materials	m^3	69	349.3	24,102	749.9	51,743
Pavement	m^2	293	654.4	191,724	2,600.3	761,889
Overlay	m^2	133	555.1	73,827	407.5	54,197
Surface & Base	m^2	245	336.0	82,320	241.0	59,045
Shoulder	m^3	214	304.4	65,143	372.6	79,732
Bridge Medium	m^2	4400	5.2	22,968	21.4	94,308
Long	m^2	6500	8.0	52,260	20.4	132,600
Phuket New Bridge				290,400 1/		500,000
Drainage & Misc.				128,230		328,370
Sub-Total (1)				1,064,089		2,430,043
Land Acquisition				137,852		184,720
Sub-Total (2)				1,202,000		2,615,000
Engineering (2) x 5%				60,000		131,000
Contingency (2) x 10%				120,000		261,000
GRAND TOTAL				1,382,000		3,007,000

1/ Total cost of Phuket New Bridge, 440 million baht, is allocated to road and railway. Road bears 66 percent in accordance with the square meters that road occupies.

Source: The Team

percent. The number of passengers originated from Surat Thani Station was 738,000 persons. Passengers carried by Khiri Ratthanikhom Spur Line was 100,300 in 1982.

For the purpose of attaining higher train operating speed, the following improvements are now in progress on the Southern Line :

- To substitute light rail (70-80 lbs/yard) to heavier rail (80-100 lbs/yard)

- To substitute wooden sleeper to concrete sleeper

- To increase the thickness of ballast from 20 cm to 25-30 cm

- To lengthen the siding to 500 m

- To improve the signalling and telecommunication system

Through these measures, the existing design speed of 70 to 80 kilometers per hour is going to be increased to 90 kilometers per hour. The average operating speed is expected to be 60 to 70 kilometers per hour after the improvement. On top of these, there is a plan to double track the line between Bang Sue and Nakhon Pathom in the first phase and between Nakhon Pathom and Pak Tho in the second phase, taking into account that train operations are often delayed due to the congested traffic in the vicinity of Bangkok.

Considering that East-West Rail Link is expected to serve for the long haul transportation, especially for the transportation between Bangkok and cities on the Andaman Sea Coast, the improvement of the Southern Line itself is very important. The improvement described in the above paragraph should be accelerated and further improvements will become necessary for attracting more freight and passenger.

Though Bang Sue Station is going to rebuilt from the conventional cargo handling yard to modernized container terminal, cargo handling yard and facilities of the remaining stations are left behind in terms of efficient transportation. Modernized cargo terminals should be located at selective major stations and special freight trains should be operated among these terminals. Loading/Unloading of freight and marshaling of freight trains are the area that more improvements are needed. Good interface between railway and trucks is another important element for efficient collection and distribution of freight. Expected railway distance from Bangkok to Phuket is 830 kilometers. If passenger trains are operated at the present average speed, train will take about 16 hours, being more time consuming than bus by two hours. However, the travel time will be reduced to less than 13 hours if the average speed is increased through the aforementioned improvements.

2) Design Standard

Design standard adopted to Chachoengsao-Sattahip Rail Link is applied to this study on the ground that this rail link is the only one example newly constructed in recent years. Main features are as follows :

Track	Single track
Gauge	1 m
Axle design load	20 ton
Rail	80 lbs/yard
Maximum design speed	100 km/H
Maximum gradient	1%
Maximum curve radius	800 m
Sleeper and spacing	PC sleeper at 0.60 m interval for main line and 0.65 m for other tracks

3) Geometric Design of Alignment

Basic concept to select railway location is to follow a straight line of flat terrain as much as possible. However, it is very common that natural and social conditions such as terrain, soil, and communities will not allow the location to follow this concept. Within the limit of these conditions, the route considered to be most economical was tried to find out as shown in Figure 5.7(2).

Thung Pho Junction (631.0 kilometers) - Khiri Ratthanikhom (662.0 kilometers)

East-West Rail Link uses the existing Spur Line by improving rail and sleeper. The terrain is almost flat and the number of curves is very limited. A new connecting link is proposed to connect East-West Rail Link to the direction of Bangkok at Thung Pho Junction Area so as to facilitate the train operation and ease the traffic concentration on Thung Pho-Phun Phin Section. Provision of siding to the proposed industrial estate will further increase the role of East-West Rail Link.

Khiri Ratthanikhom (662.0 kilometers) - Ban Khao Thao (743.5 kilometers)

The link of this section lies between Route 4040 and the mountain chain directed to the Phangnga Bay. The link is located away from the mountain as far as possible to avoid rolling terrain and probable landslide. Maximum gradient of one percent is kept with some difficulty in this section.

Ban Khao Thao (743.5 kilometers) - South of Phangnga (751.0 kilometers)

This section is in mangrove area with soft foundation. Judging from the condition of Provincial Highway Route 4144, however, embankment is considered possible with some countermeasure to settlement.

South of Phangnga (751.0 kilometers) - Phuket New Bridge (788.0 kilometers)

This section has no special problem. Rolling terrain with minor degree will need some

cut and fill. According to the original alignment proposed by State Railway of Thailand (SRT), the railway link was directed to the existing Sarasin Bridge. Due to the programmed extension of runway of Phuket International Airport, however, the alignment will be forced to return to the east again in Phuket Island. Direct connection on the eastern side will contribute more to the construction economy.

Phuket New Bridge (788.0 kilometers) - Phuket Bypass (815.0 kilometers)

The link of this section passes the western side of Highway Route 402 with a distance of 200-1,000 meters from the highway. Because of the mountains situated in the center of the island, available range for route selection is very limited.

Phuket Bypass (815.0 kilometers - 820.0 kilometers)

Phuket Bypass Project is now in progress in this section, lying in a narrow strip between mountain and canal. The railway link has no choice but to locate at the opposite side of the canal because the location at mountain side will necessitate huge quantity of cutting.

Phuket Bypass (820.0 kilometers) - Phuket Deep Seaport (831.5 kilometers)

After passing through the bypass section, the link turns to the east and approaches to Phuket Deep Seaport through a narrow strip between Route 4023 and mountain. Substantial quantity of cutting becomes inevitable in this strip.

4) Geometric Design of Cross Section

The typical cross sections adopted in this study are as shown in Figures 5.12 through 5.14. For the embankment on the soft ground, counter weight berm is proposed against settlement.

5) Station

At this study stage, stations are located mainly for the purpose of providing a siding to facilitate passing/crossing of trains. Stations are planned at the existing stations on Khiri Ratthanikhom Spur Line and at intersections with major highway and community centers on the new extension line. The effective length of siding is estimated at 700 meters in consideration of the maximum length of freight train and leeway. The length of platform is decided at 250 meters for accommodating passenger train. Outline of these stations are as shown in Figure 5.15. 19 stations are arranged on the whole length of East-West Rail Link, the average distance between stations being about 10 kilometers.

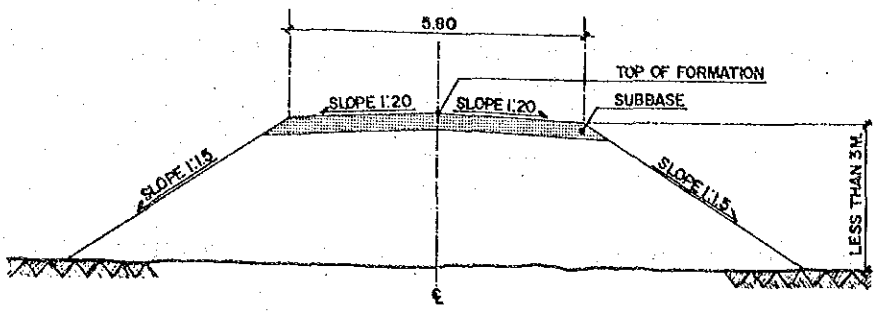


Fig. 5.12 TYPICAL CROSS SECTION ON NORMAL SOIL CONDITION (RAIL LINK)

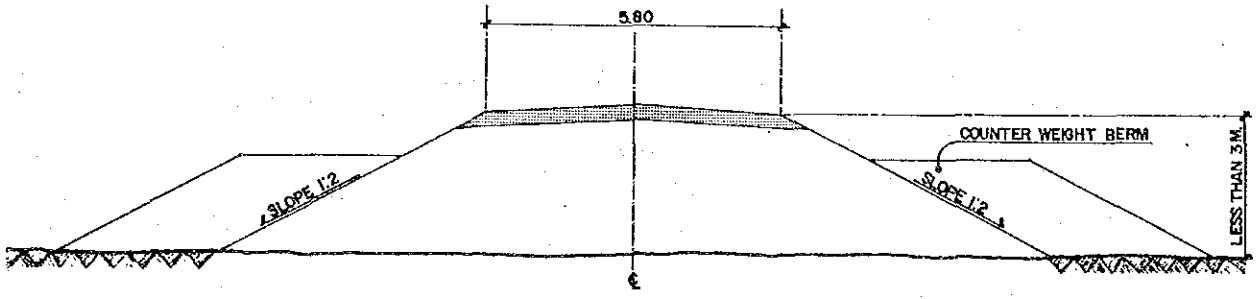


Fig. 5.13 TYPICAL CROSS SECTION ON SOFT GROUND (RAIL LINK)

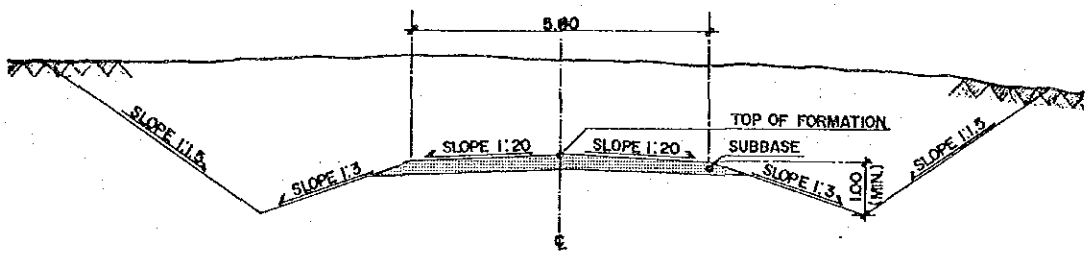


Fig. 5.14 TYPICAL CROSS SECTION IN CUTTING (RAIL LINK)

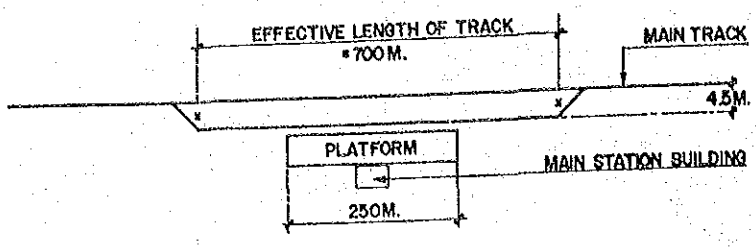


Fig. 5.15 TRACK LAYOUT OF INTERMEDIATE STATION

Considering that Phuket Station will be one of the major stations on East-West Rail Link from the aspect of both passenger and freight traffic, more facilities are provided to Phuket Station as shown in Figure 5.16.

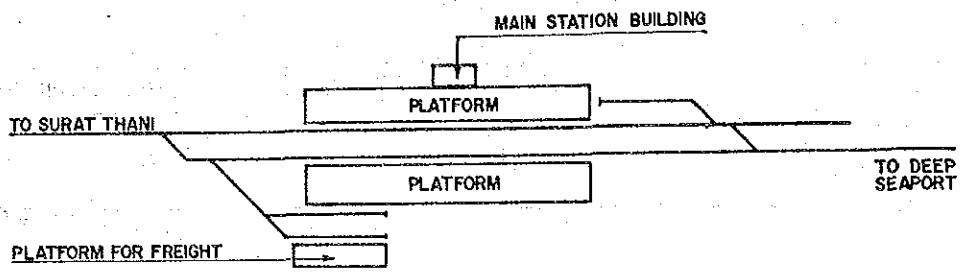


Fig. 5.16 TRACK LAYOUT OF PHUKET STATION

6) Signalling and Telecommunication

Signalling system is essential to improve the safety and efficiency of train operation. Telecommunication system is essential for smooth train operation, appropriate dispatching, prompt restoration of damages by accident, and improvement of transportation service. Improvement of signalling and telecommunication system contributes greatly to the increase of rail capacity through allowing higher operating speed of trains.

As for signalling system, the Southern Line consists of 43 percent of tokenless and 57 percent of token block system at present. As for communication system, almost all transmission lines are composed of open wires and open-wire carrier equipment. Improvement of the existing system is now in progress in accordance with the Fifth Five Year Plan of SRT.

Modernized electric signalling and telecommunication system is to be installed on newly constructed Chachoengsao-Sattahip Line. Taking account of the improvement of the existing system and the installation of highly efficient system on Chachoengsao-Sattahip Line, it is presumed that the same signalling and telecommunication system with Chachoengsao-Sattahip Line will be adopted to East-West Rail Link.

7) Construction Cost

Based on the studies described in the above, construction cost between Ban Thung Pho Junction and Phuket Deep Seaport is estimated as shown in Table 5.11. Total construction cost is estimated at 1,442 million baht in 1983 price.

Table 5.11 CONSTRUCTION COST OF EAST-WEST RAIL LINK

Unit: 1,000 baht at 1983 price

Item	Amount	Remarks
Subgrade	151,607	Embankment, Excavation, Subbase, Top Soil, Clearing & Grubbing
Track	590,616	Rail, Sleeper, Ballast, Turnout
Bridge	248,091	Inclusive of 34% of Phuket New Bridge
Station	9,916	Platform, Station Building
Signal/Telecom.	89,300	
Sub-Total (1)	1,089,530	
Land	164,715	
Sub-Toral (2)	1,254,000	
Engineering (2) x 5%	63,000	
Contingency (2) x 10%	125,000	
Grand Total	1,442,000	

Source: The Team

8) Rolling Stock

Based on the transportation demand forecast for 2000, the required number of freight and passenger trains are estimated as described in Chapter 5.2. The required number of rolling stocks by type is then estimated on the basis of the above estimations and the present efficiency of diesel locomotives, freight cars and passenger cars by using the following formulas :

Diesel Locomotives for Freight Train (DLF)
= (Freight Train km per day) / (Diesel Locomotive km per engine in service per day)

Diesel Locomotives for Passenger Train (DLP)
= (Passenger Train km per day) / (Diesel Locomotive km per engine in service per day)

Freight Cars (FC)
= (0.5 x FC Train km per day x Average number of FCs per train)/ (FC kilometers per car in service per day)

Passenger Cars (PC)
= (PC train km per day x Average number of PCs per train)/
(PC km per car in service per day)

The number of rolling stocks required in 2000 is estimated as shown below :

Diesel Locomotives	for Freight Train	12
	for Passenger Train	4
	Total	16
Freight Cars		424
Passenger Cars		33

Expense for purchasing rolling stocks is estimated at 1,291.4 million baht by the year 2000 as shown in Table 5.12.

Table 5.12 PURCHASING EXPENSE FOR ROLLING STOCK BY 2000

		1000 baht	
	Q'ty	Unit price	Amount
Diesel Locomotive	16	34,300	548,800
Freight Car	424	1,300	551,200
Passenger Car	33	5,800	191,400
Total			1,291,400

Source: The Team

5.2.5 Preliminary Evaluation

1) Development Alternatives

According to the traffic demand forecast shown in Table 5.5, the average daily traffic on East-West Road Link is estimated at 6,000 and 7,000 passenger car units in 2000 for the cases with and without railway, respectively. The estimated daily traffic in 2000 is considered to be still less than the capacity of two lane highway. Considering the period necessary for constructing East-West Link, however, the time when East-West Link is opened to traffic will fall in the period of 1991 to 1995. The year 2000 is only five to ten years after the completion of East-West Link. Traffic demand will continue to increase after the year 2000 and in another five to ten years the average daily traffic will exceed the capacity. Additional capacity will become necessary by 2005 to 2010.

Taking the above into consideration, the development alternatives for East-West Link are derived as shown below :

Without:Prototype East-West Road Link at the end of the Fifth Five-Year Plan period

Alternative 1:New railway link with developed East-West Road Link of two lanes

Alternative 2:Developed East-West Road Link of four lanes

2) Method of Evaluation

The evaluation criterion used for comparing benefit and cost streams is internal rate of return (IRR), which is defined as the discount rate at which the total discounted costs are equal to the total discounted benefits.

Benefits taken into consideration are energy saving and/or vehicle operating cost (VOC) saving created by the implementation of East-West Link Project. The kind of benefits created by each alternative can be summarized as follows :

Benefits to be created by Alternative 1

-Energy saving through the diversion from road to railway

- VOC saving by the reduction in road distance (sections of Surat Thani-Route 41 and Phuket New Bridge)

- VOC saving by the relocation of the link from hilly/mountainous area to flat area (sections of Surat Thani-Route 41 and Route 41-Phanom)

- VOC saving created by improved travelling speed of vehicles which is expected to be attained by reduced traffic volume through the shift from road to railway

Benefits to be created by Alternative 2

- VOC saving by the reduction in road distance (same as Alternative 1)

- VOC saving by the relocation of the link from hilly/mountainous area to flat area (same as Alternative 1)

- VOC saving created by improved travelling speed of vehicles which is expected to be attained through the capacity increase of East-West Road Link

Costs taken into consideration are the construction cost and periodic and routine maintenance costs for road, and the construction cost, expenses for purchasing trains and maintenance cost for railway. Construction cost of "without project" case consists of strengthening the pavement of provincial road and widening the carriage way to seven meters, where necessary.

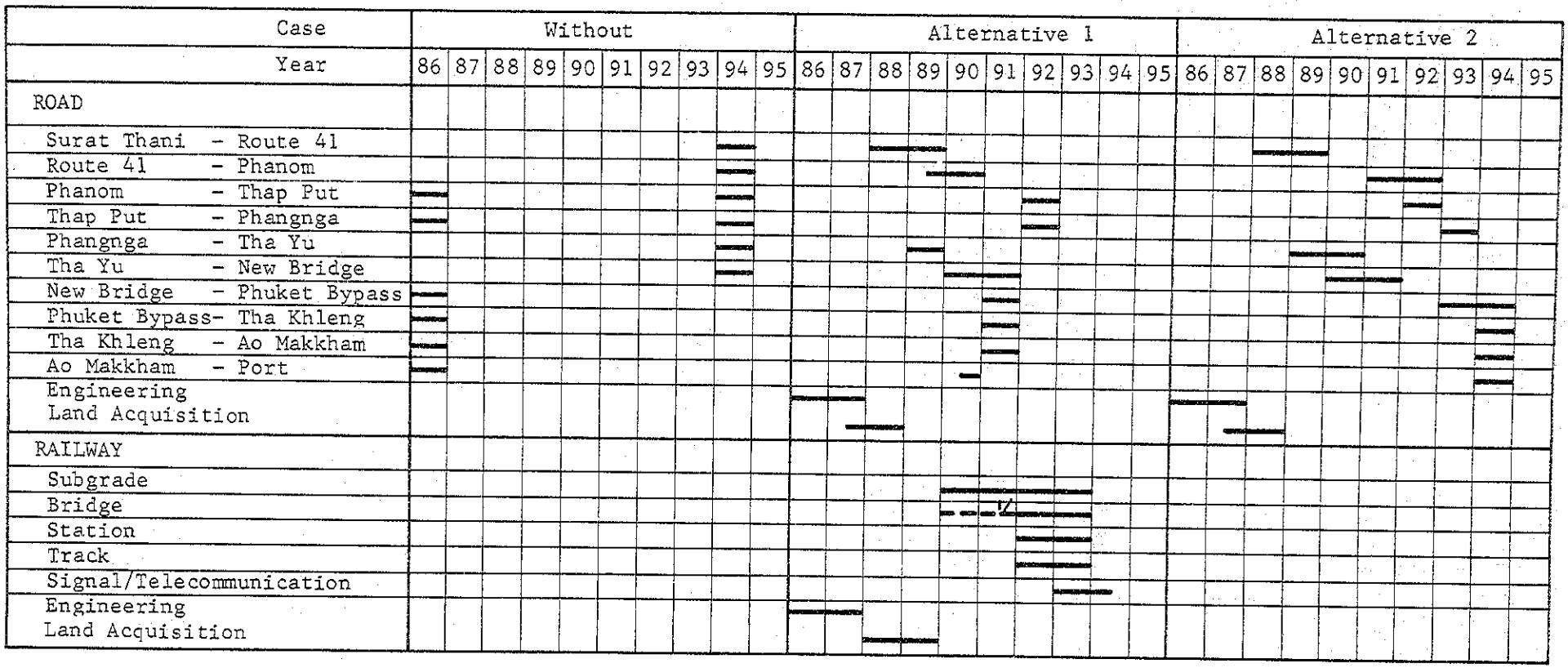
Project life is assumed at 25 years after the completion of the whole stretch.

Development phasing of each case is established as shown in Figure 5.17. The year when the whole stretch of both alternatives are completed is assumed to be 1994.

As for "without project" case, the improvement/development programs under the Fifth Five-Year Plan will be completed by 1986. To accommodate heavy vehicles and increasing traffic, strengthening of pavement of provicial highway and widening of carriage way are assumed in 1994.

As for "with project" cases, a crucial factor in determining the schedule is the timing of constructing Phuket New Bridge. In Alternative 1, most sections of road development are planned before the completion of Phuket New Bridge and most works of railway development are planned after the completion of the bridge. In Alternative 2, the sections of Surat Thani-Route 41 and Phangnga-Tha Yu (Route 4) are planned

Fig. 5.17 DEVELOPMENT PHASING OF EAST-WEST LINK



1/ Phuket New Bridge for railway is constructed together with that for road.

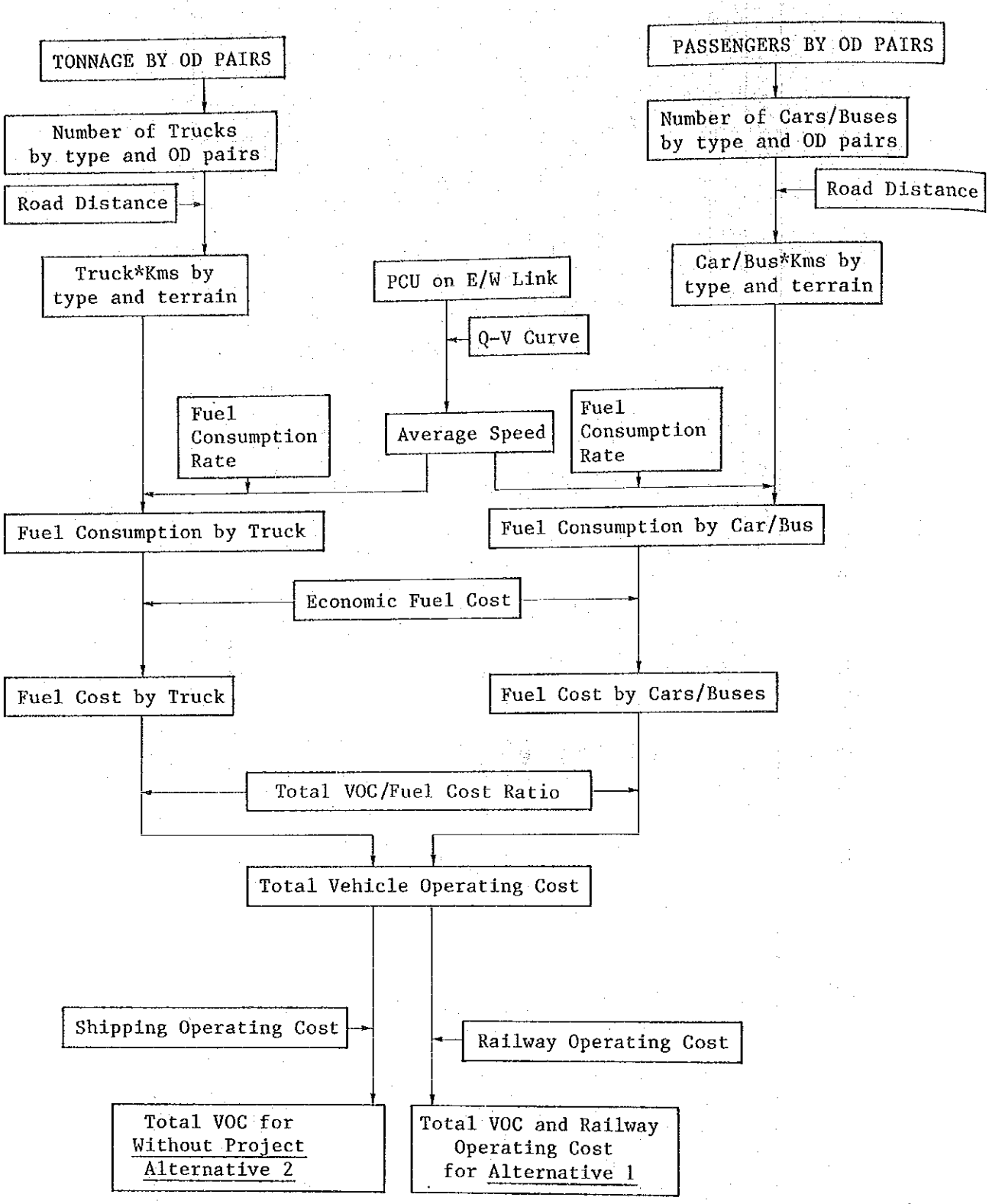


Fig. 5.18 PROCEDURE TO ESTIMATE ECONOMIC OPERATING COST FOR ALTERNATIVES

prior to the completion of Phuket New Bridge, taking into account that the construction of the former section is already planned by DOH to ease the traffic congestion between Surat Thani and Phun Phin, and that the latter section is considered to fall on the time for periodic maintenance.

The above mentioned benefits, costs and development phasing are incorporated to calculate the internal rates of return for the two alternative cases.

3) Benefit Estimation

For benefit estimation, transportation demand estimated for 1980 and 2000 were arranged to cover the period of the assumed project life. Firstly, transportation demand in 1991 was estimated by allocating the increment of transportation demand from 1980 to 2000 in propor- tion to the growth rates of GDP and population of the period 1980-1991 as against the period 1980-2000. Secondly, transportation demand in 1995 and 2005 was estimated by interpolation and extrapola- tion at the growth rate of transportation demand over the period of 1991-2000. Transportation demand in 2015 was estimated by applying a half of the growth rate over the period of 1991-2000 and no increase for the years afterwards. Benefit streams were estimated on the basis of transportation demand in 1995, 2005 and 2015.

Transportation demand on East-West Road Link was converted to vehicle operating cost (VOC) on East-West Road Link by following the proce- dure as shown in Figure 5.18.

Train operating cost was estimated separately based on ton kilometers and person kilometers to be carried by railway. Total operating cost under Alternative 1 is composed of vehicle operating cost on East-West Road Link and train operating cost. Total operating cost under "without project" case and Alternative 2 is composed of vehicle operating cost on East-West Road Link and operating cost to transport cargoes which will not appear on East-West Road Link, namely, cement from Thung Song to Phangnga and Phuket and export cargoes from the Western Region to the western situated countries. Total operating cost under each case is as shown in Table 5.13.

Table 5.13 TOTAL OPERATING COST OF EAST-WEST LINK

Unit: Million baht

	Without			Alternative 1			Alternative 2		
	1995	2005	2015	1995	2005	2015	1995	2005	2015
VOC on E/W Link	1990.1	3626.7	4997.7	1038.8	1969.0	3068.9	1849.9	3038.7	4062.3
Transport of Cement	8.1	16.4	20.7	–	–	–	8.1	16.4	20.7
Transport of Export Cargo	106.4	141.7	163.6	–	–	–	106.4	141.7	163.6
Railway Operating Cost	–	–	–	312.6	469.3	576.3	–	–	–
Total	2104.6	3784.8	5182.0	1351.4	2438.3	3645.2	3196.8	3196.8	4246.6

Source: The Team

4) Cost Estimation

Yearly construction cost of East-West Road Link was estimated based on the cost estimation presented in Table 5.10 and development phasing shown in Figure 5.17, and that of East-West Rail Link was also estimated based on the cost estimation in Tables 5.11 and 12 and development phasing in Figure 5.17. Expenses for purchasing diesel locomotives and freight/passenger cars were allocated to every five years in accordance with the estimated transportation demand. Salvage values of land for new construction section and locomotives/train cars were deducted from the cost at the end of the project life because the land has opportunity usage for other purposes and renewed locomotives/train cars have enough remaining period for use.

Maintenance cost of road consists of two kind of maintenance, periodic and routine maintenance. Periodic maintenance is supposed to be carried out at every eight years and routine maintenance at every year. Maintenance cost of railway consists of maintenance of way and structure and maintenance of equipment.

Cost and benefit streams for the period of project life is as shown in Table 5.14.

5) Economic Analysis

Based on the cost and benefit streams, Internal Rates of Return (IRR) are calculated at 18.4 percent for Alternative 1 (railway with two lane highway) and 11.1 percent for Alternative 2 (four lane railway).

Table 5.14 ECONOMIC COST AND BENEFIT COMPARISON

Unit: million baht

		(1)Const./Maint. Cost			(2)Operating Cost			(3)Cost		(4)Benefit	
		Without	Alt.1	Alt.2	Without	Alt.1	Alt.s	Alt.1	Alt.2	Alt.1	Alt.2
1	1984	-	-	-	-	-	-	-	-	-	-
2	85	-	-	-	-	-	-	-	-	-	-
3	86	-	-	-	-	-	-	-	-	-	-
4	87	93.9	104.6	122.9	-	-	-	10.7	29.0	-	-
5	88	7.1	256.0	245.1	-	-	-	248.9	238.0	-	-
6	89	7.1	237.1	214.7	-	-	-	230.0	207.6	-	-
7	1990	7.2	457.8	430.8	-	-	-	450.6	423.6	-	-
8	91	7.2	377.1	582.6	-	-	-	369.9	575.4	-	-
9	92	7.2	571.7	550.9	-	-	-	564.5	543.7	-	-
10	93	7.2	411.1	274.7	-	-	-	403.9	267.5	-	-
11	94	234.0	894.2	183.4	-	-	-	660.2	-50.6	-	-
12	95	7.2	88.5	6.5	2104.6	1351.4	1964.4	81.3	-0.7	753.2	140.2
13	96	7.2	91.8	6.5	2231.8	1433.6	2062.4	84.6	-0.7	798.3	161.8
14	97	7.2	110.0	35.5	2366.7	1520.7	2165.3	102.8	28.3	846.0	186.8
15	98	7.2	160.7	51.5	2509.8	1613.2	2273.4	153.5	44.3	896.6	215.5
16	99	7.2	148.5	31.2	2661.5	1711.2	2386.8	141.3	24.0	950.2	248.8
17	2000	7.2	349.6	160.6	2822.3	1815.2	2506.0	342.4	153.4	1007.1	287.1
18	01	7.3	111.2	47.9	2992.9	1925.6	2631.0	103.9	40.6	1067.3	331.4
19	02	205.3	115.5	75.6	3173.8	2042.7	2762.3	-89.8	-129.7	1131.1	382.5
20	03	7.3	120.0	7.0	3365.6	2166.8	2900.1	112.7	-0.3	1198.8	441.4
21	04	7.3	124.7	7.0	3569.1	2298.6	3044.9	117.4	-0.3	1270.5	509.5
22	05	7.3	392.3	35.7	3784.8	2438.3	3196.8	385.0	28.4	1346.5	588.0
23	06	7.3	193.7	51.7	3905.6	2538.3	3288.9	186.4	44.3	1364.4	615.9
24	07	7.3	180.3	31.3	4030.3	2642.5	3383.6	173.0	24.0	1382.6	645.2
25	08	7.3	197.2	160.8	4158.9	2750.9	3481.1	189.9	153.5	1401.0	675.9
26	09	7.3	140.2	48.0	4291.7	2863.8	3581.3	132.9	40.7	1419.6	708.0
27	2010	205.3	278.0	75.7	4428.6	2981.3	3684.5	72.7	-129.6	1438.5	741.6
28	11	7.4	145.8	6.8	4570.0	3103.6	3790.6	138.4	-0.6	1457.6	776.9
29	12	7.4	148.7	6.8	4715.9	3231.0	3899.8	141.3	-0.6	1477.0	813.8
30	13	7.4	166.2	35.8	4866.4	3363.5	4012.1	158.8	28.4	1496.7	852.5
31	14	7.4	216.4	51.7	5021.7	3501.5	4127.7	209.0	44.3	1516.6	893.0
32	15	7.4	719.9	31.4	5182.0	3645.2	4246.6	712.5	24.0	1536.8	935.4
33	16	7.4	220.7	160.9	5182.0	3645.2	4246.6	213.3	153.5	1536.8	935.4
34	17	7.4	164.2	48.1	5182.0	3645.2	4246.6	156.8	40.7	1536.8	935.4
35	18	205.3	167.4	75.8	5182.0	3645.2	4246.6	-37.9	-129.5	1536.8	935.4
36	19	7.4	-907.8	-196.4	5182.0	3645.2	4246.6	-915.2	-203.8	1536.8	935.4
Total		1147.6	7153.3	3658.4	97482.0	65519.7	82376.0	6005.7	2510.8	31903.6	14892.8

Source: The Team

Economic benefit of Alternative 1 consists mostly of the operating cost saving through the diversion of transportation demand between the Upper South and Bangkok from road to railway. The IRR will be reduced to 16.1 percent by 20 percent cost increase and 15.6 percent by 20 percent benefit reduction. Combined effects of cost increase and benefit reduction of 20 percent each will reduce the IRR to 13.4 percent. Net Present Value (NPV) for Alternative 1 is calculated at 1,109 million baht, and Benefit Cost Ratio (BCR) at 1.7 at a discount rate of 12 percent.

Economic benefit of Alternative 2 consists of the operating cost saving through the smooth traffic flow on East-West Road Link owing to the expanded traffic capacity. Though the IRR of 11.1 percent is slightly less than the prevailing discount rate, it will be improved by introducing a phasing development program; to construct two lane highway in the right of way for four lanes at the first stage, and to construct additional two lanes afterwards in accordance with the future increase of traffic demand. Under the present conditions, NPV for Alternative 2 is calculated at minus 127 million baht, and BCR at 0.9 at a discount rate of 12 percent.

Judging from the above economic indicators, it can be concluded that East-West Link is very viable from the viewpoint of national economy. Railway extension to Phuket Deep Seaport coupled with improvement/development of two lane highway (Alternative 1) is considered to be more contributive to national economy than the development of four lane highway (Alternative 2).

However, taking account of the huge investment cost required for the establishment of East-West Link (4,115 million baht including rolling stocks for Alternative 1 and 3,007 million baht for Alternative 2), it is advisable to proceed to further detailed studies. Each component of this preliminary study still contains rooms to be further elaborated; transportation demand especially in relation with internationalization and industrialization, cost estimation in terms of quantity and unit price, and development phasing with due consideration to transportation demand, capacity of construction works and financial aspects.

5.3 PORT DEVELOPMENT

5.3.1 Upper South in the International Shipping Environment

1) International Shipping Route

Over the last 10 to 15 years, international liner shipping experienced container revolution, through which the third generation container transport system was established.; fully containerized vessels with 20 to 25 knot speed, satellite navigation and computerized control of machinery and cargo handling. They keep to rigid time tables, turnaround time in port being counted in hours rather than in days. The intermodal concept in which sealed containers travel from factory to consignee via road, rail and ship with through bills of lading for minimum documentation and time consumption has become normal practice. The third generation container vessels of 40,000 to 50,000 Dead Weight Tons (DWT) have entered service among such liner ports as Singapore, Hong Kong, Kobe and Yokohama in Asian Region. The Port of Singapore is the most important liner port in South East Asia. Most of export and import cargoes are centered there for transshipment to various destinations.

Container services in and out of Bangkok are all by feeder vessels of 10,000 to 15,000 DWT to connect with liner services in Singapore for westbound traffic and Hong Kong or Japanese Ports for eastbound traffic. International shipping routes are illustrated in Fig. 5.19.

Southern Thailand including the Upper South is located near international shipping routes on both the Gulf of Thailand side and the Andaman Sea side. It is quite possible that feeder container vessels will call at deep seaports in the South with only a small diversion off the route. Partial or semi container ships on tramper basis can offer direct services to the final destinations as well.

2) Port Development on Malay Peninsula

From the Port of Singapore, situated at the southernmost point of Malay Peninsula, two major ports, Kelang Port and Penang Port, are located at 300 kilometer intervals on the Andaman Sea Coast. Phuket Deep Seaport is planned to be located at another 300 kilometers from Penang Port. Kelang Port has 26 berths with total berth length of 4.7 kilometers. Two container berths are provided to accommodate full container vessels of 40,000 to 50,000 DWT. Penang Port has nine berths with total berth length of 1.6 kilometers. One container berth is provided to accommodate partial or semi

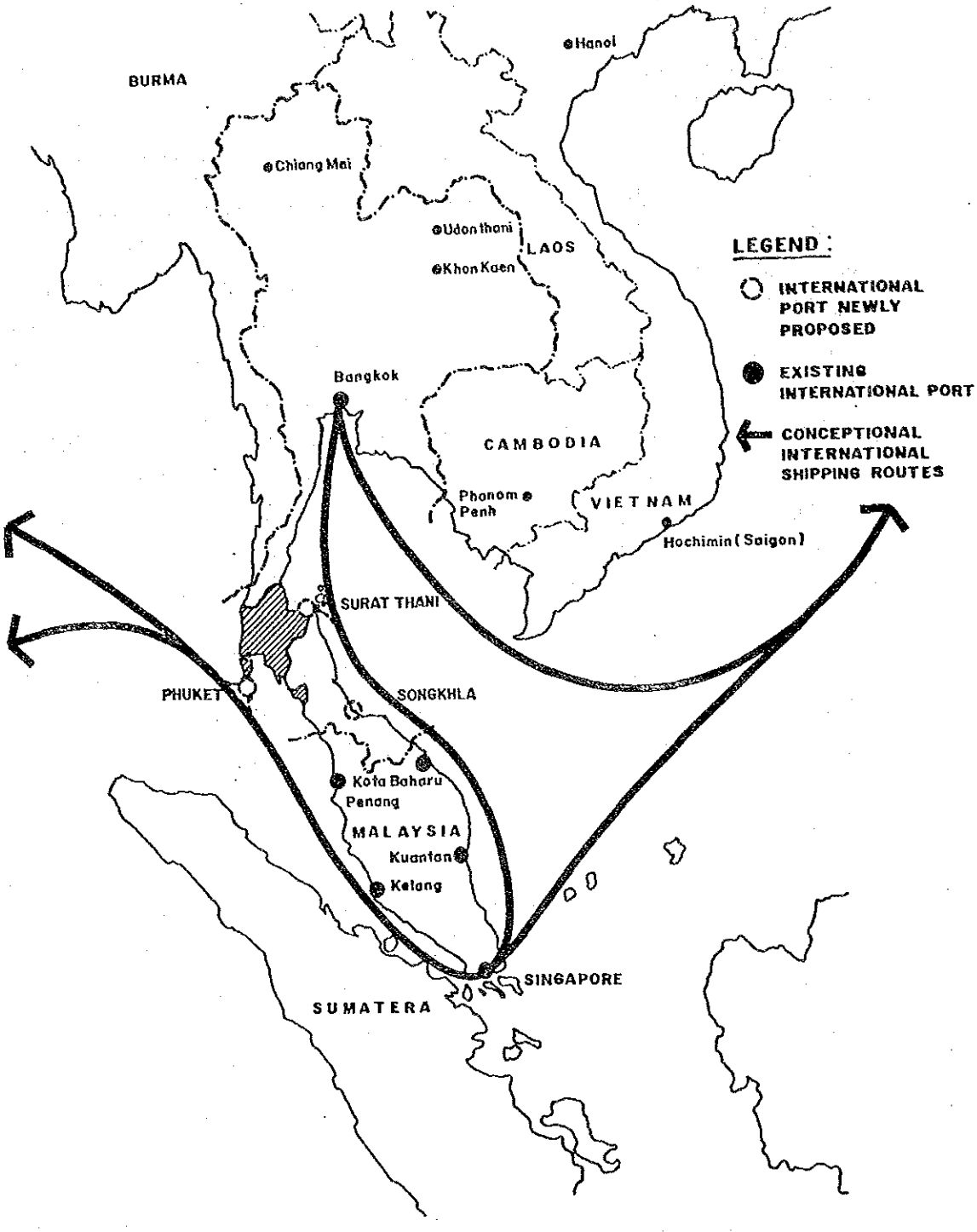


Fig. 5.19 INTERNATIONAL SHIPPING ROUTE AND PORTS ON MALAY PENINSULA

container vessels of 15,000 DWT at present, but additional two container berths are to be constructed by 1986 for accommodating full container vessels. These two ports are contributing to a great extent to ensuring smooth and efficient export of primary products of Malaysia.

From the Port of Singapore, Kuantan Port and Kota Baharu Port are located at 300 kilometer intervals on the Gulf of Thailand coast. Songkhla Deep Seaport is planned to be located at another 300 kilometers distance from Kota Baharu Port. Khanom Area is situated at further north from Songkhla, the approximate distance being 300 kilometers. Kuantan Port with six berths was constructed in 1974, and rehabilitation and reconstruction were implemented in recent years for attaining smoother flow of cargo into and out of the country.

Judging from both the international shipping route along the Malay Peninsula and port development on the peninsula, it can be concluded that Phuket, Songkhla and Surat Thani have substantive possibility to open new international port. Considering keen competitions among ports for inviting ocean going liners, these potential international ports should start operation at earlier timing to keep abreast of competitive ports.

As recognized generally, cargo transshipment with mother vessels at Singapore is time consuming and expensive. Even though there is little hope for direct trunk liner shipping services to Thailand in the foreseeable future, it is very necessary to seek for measures to tackle with this problem. Modernizing port facilities and infrastructure and providing better port administration and procedure will be one issue and developing international ports near international shipping route will be another.

5.3.2 Khanom Deep Seaport

1) Roles and Functions Required

With the advent of the era of internationalization, the roles of ports have become more important than ever. Cost retrenchment by appropriate port location and efficient cargo handling have the immediate effect of lowering prices, benefiting consumers and allowing competitively favourable prices for export goods. The smooth functioning of ports as a junction between sea and land transportation results in stabilized and abundant consumer life for the people of the country and substantially helps the nation's economic expansion by increasing its exports.

To achieve economic expansion, it is necessary to develop highly productive secondary industries. Of course, improving the productivity of primary industries through technical renovation is also important and greatly contributes toward the stabilization of the economy through food self-sufficiency and acquisition of foreign currencies. At the same time, a balanced economic structure can be realized and steady economic growth can be achieved by developing secondary industries thereby enabling them to absorb more labour and yield higher added value. Efficiently used ports can greatly contribute to manufacturing activities, particularly manufacturing activities involving mass transportation of goods, as is the case with almost all modern industries. Port facilities and industrial sites can be integrally arranged with a view to utmost efficiency in transportation, storage and processing. Raw materials necessary for industries can be directly brought by efficient ship transportation without recourse to relay transportation and supplied via quays to the integrally arranged industrial sites. The raw materials can then be processed and the products shipped out via quays arranged with product depositories. A port of this type is not planned for a single plant but planned for a coastal zone development project, in anticipation of the construction of an industrial group that not only comprises related industries but is also necessary for the entire nation or the region concerned.

The functions required for Khanom Deep Seaport are enumerated as follows :

- To retrench relay transportation cost of primary products of the subregion to Bangkok (650 kilometers) and Songkhla (300 kilometers) for realizing more competitive prices in the international market.

- To facilitate the export of manufactured products from inland industrial estates without recourse to transshipment to Bangkok/Songkhla, thus enhancing the possibility of relocating and attracting secondary industries from Bangkok to the Upper South.

- To prepare the space for integrated development of port facilities and industrial sites for large scale industrial growth in the long run.

On the east coast, Songkhla Deep Seaport is scheduled to be completed by the end of the Fifth Five-Year Plan period. This port is expected to further promote the regional development of Hat Yai/Songkhla Area as well as to retrench inland transportation cost of primary exporting products. Though Songkhla Deep Seaport will contribute to saving inland transportation cost of primary exporting products of Surat Thani to some extent, the port will have little effect on regional development of Surat Thani

due to the long distance of 300 kilometers. Investors will find it more advantageous to invest in Hat Yai/Songkhla Area due to the well developed transportation infrastructures, possibly resulting in its accelerated economic growth and sluggish growth of the zones inbetween. Construction of new international port is considered vital to the development of Surat Thani economy. As can be recognized through the port develop- ment experience on the Malay Peninsula, the distance of 300 kilometers observed between major ports can provide an important rationale for establishing another international port. It is, however, very necessary to arrange the development phasing of the two ports in the long perspective.

2) Site Selection

Newly constructed Tha Thong Port is located at the junction point of the Tapi River and the Tha Thong River in Ban Don Bay. This port has a capacity to accommodate vessels up to 1,000 DWT only. Water channel is planned to be dredged with the length of 29 kilometers and the depth of four meters. Through siltation and drifting sand in the past centuries, the available depth along the natural channel in the bay ranges from one to 1.5 meters. The water channel to be dredged is estimated to suffer an annual deposit rate of 100,000 tons.

Owing to the shallowness and continuous siltation of the Ban Don Bay, Tha Thong Port has little possibility to be transformed into international port. It is more economical to find other suitable site for international port than to struggle to upgrade Tha Thong Port into international port.

Necessary conditions for the international port are enumerated as follows :

- To be able to accommodate ocean going vessels of at least 15,000 DWT, taking account of the size of the vessels operated between Singapore and Bangkok.

- To keep the necessary diviation from international shipping route to the minimum and to ensure the easy maneuverability of ocean going vessels. Easy maneuverability is very important for a newly developed port to attract vessels against other competitive ports, especially in its initial stage of operations.

- To keep easy the construction and maintenance work including water channel from the viewpoint of investment cost and construction technology.

- To have enough space adjacent to the port area for the integrated development of

port and industry in the long run.

- To minimize the environmental destruction which is expected to be caused by port construction, channel dredging and vessel operations.

Based on the field reconnaissance and oceanographical data, six alternative locations were identified; these are, North Ban Tha Krachai, Tha Thong, Don Sak, East Don Sak, Khanom and South Khanom.

Through the preliminary study on each alternative, East Don Sak and South Khanom are concluded to have advantages to the others. Comparison between East Don Sak and South Khanom is shown in Table 5.15. South Khanom has greater advantage than East Don Sak. It can be said that South Khanom is the only one remaining site for the seaboard industrial development along the Gulf of Thailand coast, following Eastern Seaboard.

Table 5.15 COMPARISON BETWEEN EAST DON SAK AND SOUTH KHANOM

	East Don Sak	South Khanom
Distance to International Route	50 kilometers	near
Maneuverability	difficult	easy
Length of Channel	8.5 km	2.4 km
Natural Depth of Channel	−1 m ~ −10 m	−6 m ~ −10 m
Dredging Volume	much	little
Construction Maintenance Work	difficult	easy
Future Expansion Space	some limit	vast
Impact on Fishery	minor	minor

Source: The Team

3) Port Construction Planning

(1) Cargo Handling Volume

Cargo handling volume of Khanom Deep Seaport is estimated at 823,300 tons in the year 2000. Major cargoes expected to be handled are 379,000 tons of rubber, 200,000 tons of gypsum and 244,300 tons of manufactured and miscellaneous products. In case some large scale industries are located at the area adjacent to the international

port area in the long run, handling volume of materials and products will reach a more substantial volume. The location of large scale industries, however, can not be specified at this moment, so the cargoes to and from them are not included in this estimation.

Export of rubber and gypsum is estimated to hold the share of 70 percent of the total cargo handling volume. This means that, even at the initial stage of port operation, port facilities will be utilized to a considerable extent by the export of these primary products. In due course of time, port facilities will be further utilized and will need next stage expansion in keeping pace with the activation of secondary industries in Surat Thani.

(2) Port Facilities

So as to accommodate ocean going vessels passing through the Gulf of Thailand, target size of vessel is 15,000 DWT with the overall length of 162 meters and the full load draft of 9.1 meters. Mooring facilities required for this size of vessel is 180 meters in length and minus 10 meters in depth. The diameter of turning basin reaches 360 meters. The water channel should be 120 meters in width and minus 10 meters in depth.

Additional facilities required to operate this port are oil jetty to supply ocean going vessels with fuel oil, berths for such small crafts as tugs, harbour boats and pilot boats, cargo handling equipment and transit sheds.

It is expected in the future that Surat Thani will have closer industrial relationship with Eastern Seabord and Songkhla/Hat Yai. To facilitate coastal shipping among these ports, one berth to accommodate vessels of 2,500 DWT should be prepared. It will be better to relocate the existing ferry berth at Khanom to this port area.

(3) Port Planning

The following viewpoints were taken into consideration in planning the port;

- Making best use of existing topography, especially Leam Kho Khao
- Protecting sedimentation in water channel caused by littoral drift
- Ensuring maneuverability of ocean going vessels

- Preparing enough land and water area to handle cargoes, especially container cargoes

- Adjustment with the existing jetty for shipping gypsum

- Minimizing construction and maintenance cost, especially for water channel.

Based on the above considerations, Khanom Deep Seaport is planned as shown in Figures 5.20 and 5.21. Facilities required by the year 2000 are four berths for ocean going vessels, one berth for coastal shipping, water channel of 2.4 kilometer length, 120 meter width and 10 meter depth, turning basin with a radius of 360 meters and so on. The number of berths for the first stage is one berth each for ocean going vessles and coastal shipping.

Figures 5.22 through 5.24 indicate some typical cross sections designed for cost estimation purpose. Construction cost including floating crafts and cargo handling equipment is estimated at 1,020 million baht as shown in Table 5.16. Construction phasing should be coordinated with the development of Songkhla and Phuket Deep Seaports. Considering that these two ports are scheduled to be completed by the end of the Fifth Five-Year Plan period, the first phase of Khanom Deep Seaport construction should follow their completion. This is to improve the accessibility of primary exporting products to international market through retrenchment of transshipment cost at an earlier timing and to expect the regional development effect to be generated by port development in the long run.

4) Preliminary Evaluation

The effects of port development appear interdependently in many forms including reductions in transportation cost, increases in employment opportunities, increasing incomes, improvement of living standards and regional industrialization. Reductions in transportation cost, however, is the most commonly used indicator for assessing the effects of port development because the remaining factors appear in indistinguishable form though their effects are considered substantial.

Reductions in transportation cost by Khanom Deep Seaport was estimated by comparing the inland transportation costs of "with project" case and those of "without project" case. For "with project" case, inland transportation cost was estimated for the international cargoes to be transported between Khanom Deep Seaport and products generating provinces in the South. For "without project" case, it was assumed that these cargoes would be forwarded to such substitutive ports as Songkhla, Phuket

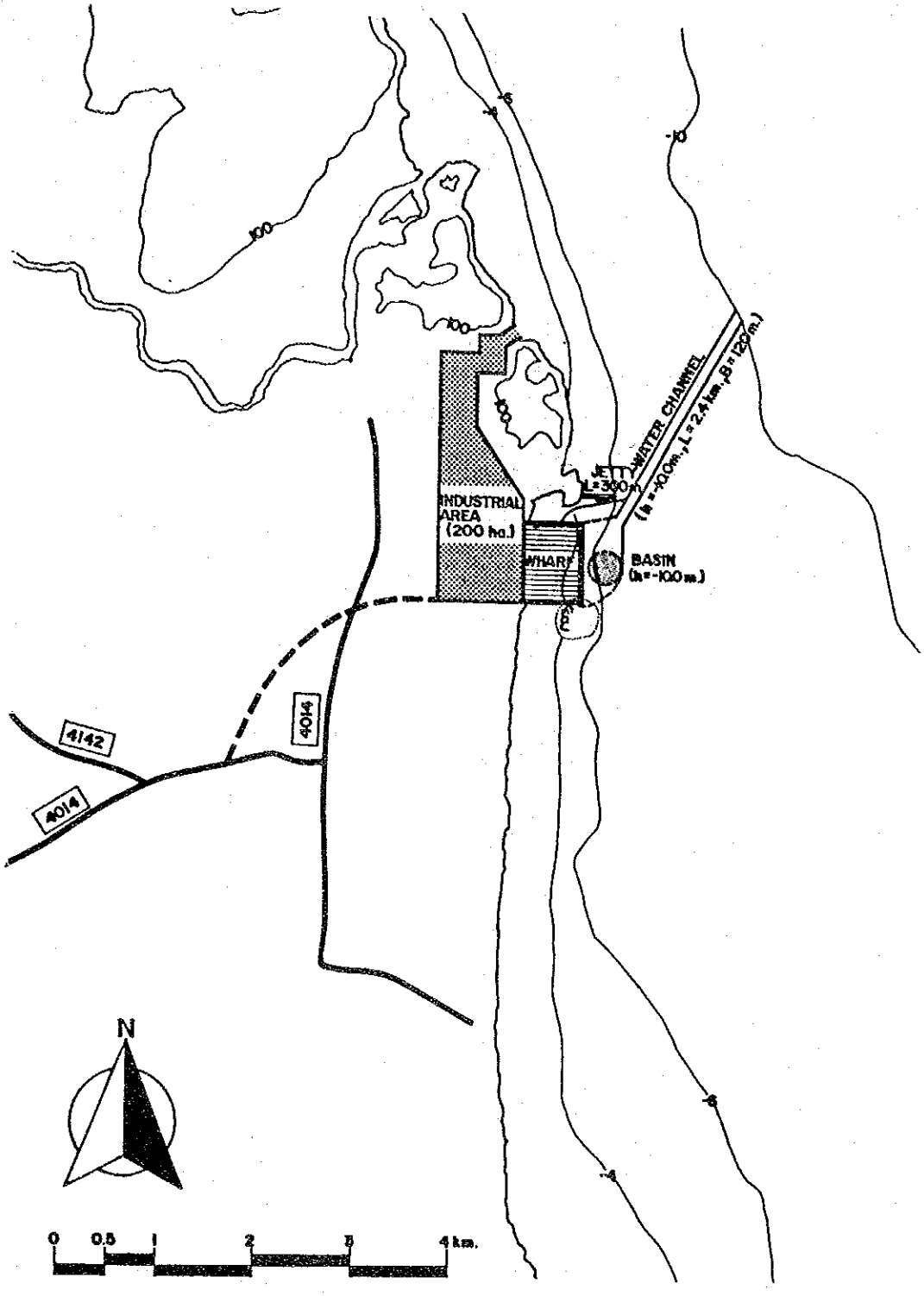


Fig. 5.20 PORT LAYOUT OF KHANOM DEEP SEAPORT

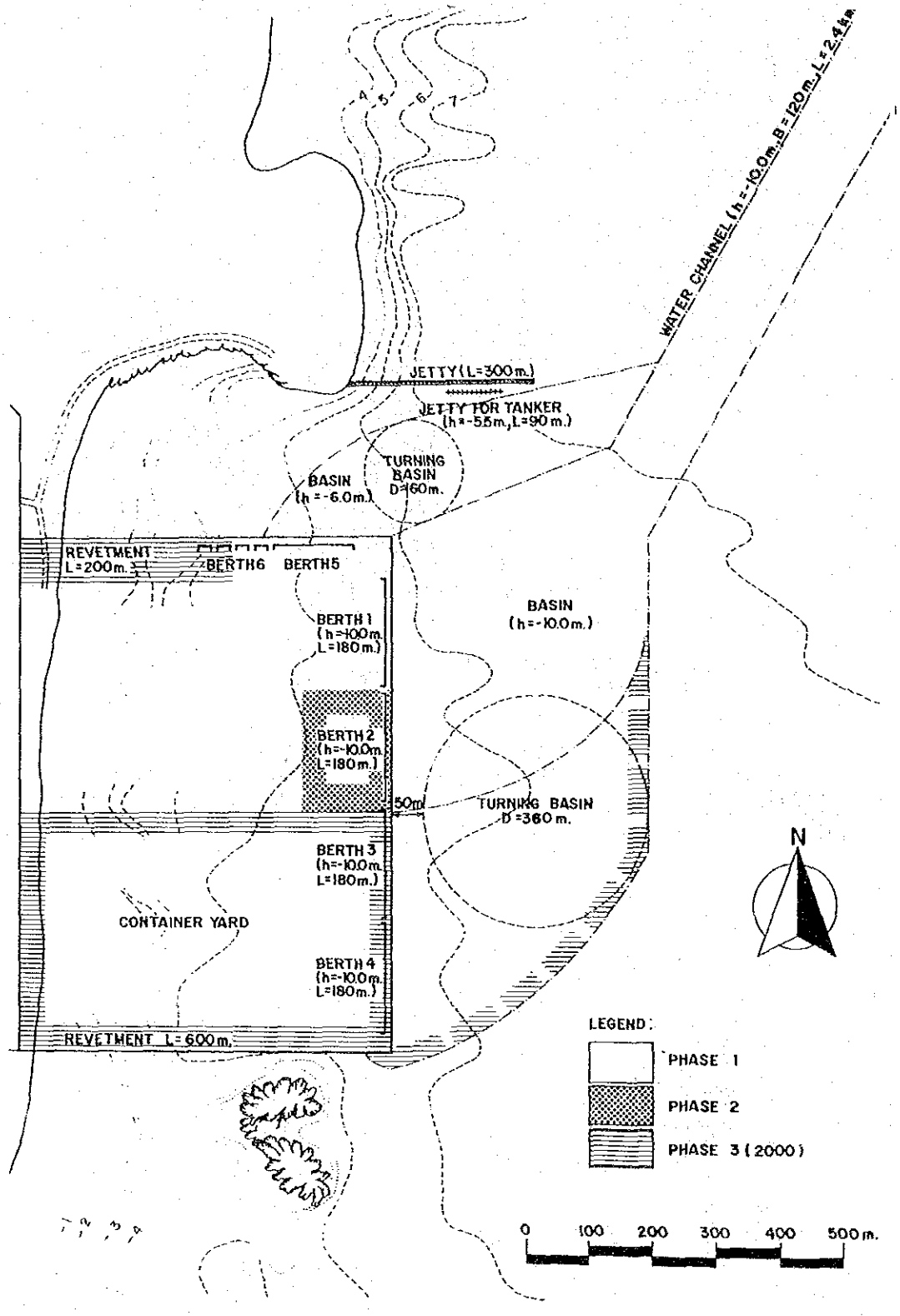


Fig. 5.21 PORT LAYOUT AND PHASING OF KHANOM DEEP SEAPORT

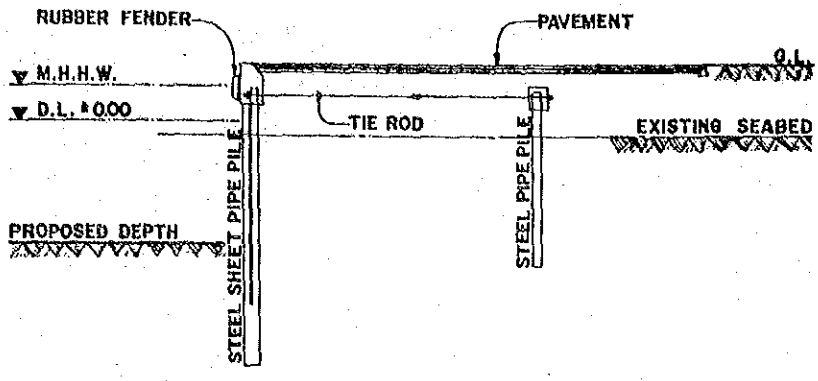


Fig. 5.22 STEEL SHEET PILE TYPE QUAYWALL
(-10.0m)

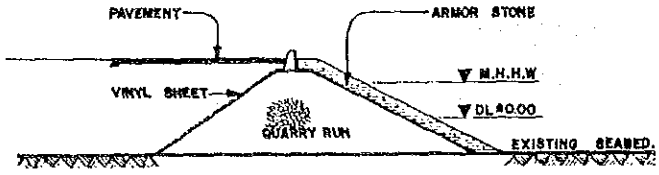


Fig. 5.23 RUBBLE MOUND TYPE REVETMENT

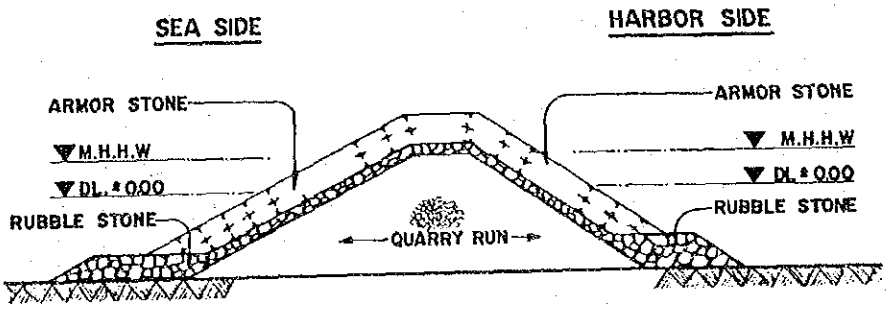


Fig. 5.24 RUBBLE MOUND TYPE TRAINING JETTY

Table 5.16 CONSTRUCTION COST OF KHANOM DEEP SEAPORT

Unit: Million baht

Cost Item	Amount	
1. Land Acquisition		2.5
2. Port Facilities		747.2
2.1 Dredging & Reclamation	102.0	
2.2 Revetment	54.0	
2.3 Quaywalls	504.5	
2.4 Buildings	22.0	
2.5 Road	10.8	
2.6 Utilities	38.9	
2.7 Training Jetty	15.0	
3. Floating Crafts		100.7
4. Cargo Handling Equipment		44.2
5. Investigation & Engineering		51.5
6. Physical Contingency		73.5
Total		1,019.6

Source: The Team

and Bangkok Ports. Gypsum was excluded from this comparison because it can be exported through the existing private jetty at South Khanom even in case of "without project".

Cost and benefit stream was estimated as shown in Table 5.17 on the premises that the construction would be phased into three stages, that operating and management cost of the port would not increase further after the completion in full scale, and that cargo handling volume could not increase any more after 2010 due to the capacity limit. Reductions in transportation cost by Khanom Deep Seaport was estimated at 66 million baht in 1991 and 132 million baht in 2000. Internal Rate of Return (IRR) of the project was calculated at 11.3 percent for the project life of 30 years. Net present value and benefit cost ratio were calculated at minus 29 million baht and 0.95, respectively, at a discount rate of 12 percent. Judging from these indicators, this project is considered to yield appropriate benefit of reductions in transportation cost to the extent that the investment will produce the return almost equivalent to an opportunity interest rate.

However, because cost/benefit analysis does not go beyond monetary evaluation of project goals, it can be said that this analysis method shows only a part of full impact

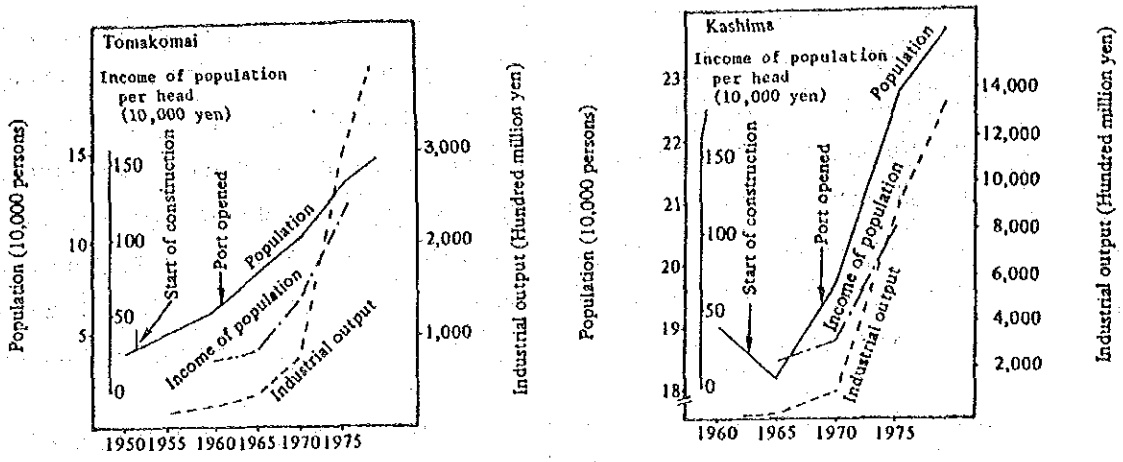
of projects where social overhead capital is created, such as port developments which spur regional socio-economic development by attracting industries and creating employment. Fig. 5.25 shows an example of regional development effect created by new port construction. Khanom Deep Seaport which has vast potential development area adjacent to the port should not be regarded only as an interface between sea and land transportation. It is an important issue that Khanom Deep Seaport be planned in such a way that new seaboard industrial development along the Gulf of Thailand coast is channeled into the port area with active relationship with Eastern Seaboard.

Table 5.17 ECONOMIC COST AND BENEFIT OF KHANOM DEEP SEAPORT

Unit: Baht

NO.	YEAR	COST	BENEFIT
1	1984	0.0	0.0
2	1985	16.5	0.0
3	1986	13.1	0.0
4	1987	134.8	0.0
5	1988	134.9	0.0
6	1989	127.8	0.0
7	1990	18.6	61.3
8	1991	18.3	66.2
9	1992	103.5	71.5
10	1993	97.8	77.1
11	1994	34.3	83.2
12	1995	34.0	89.8
13	1996	136.7	97.0
14	1997	128.2	104.7
15	1998	128.2	113.0
16	1999	40.4	121.9
17	2000	40.4	131.6
18	2001	40.4	142.0
19	2002	40.4	153.3
20	2003	40.4	165.5
21	2004	40.4	178.6
22	2005	40.4	192.8
23	2006	40.4	200.3
24	2007	40.4	208.1
25	2008	40.4	216.2
26	2009	40.4	224.6
27	2010	40.4	233.3
28	2011	40.4	233.3
29	2012	40.4	233.3
30	2013	40.4	233.3
31	2014	40.4	233.3
32	2015	40.4	233.3
33	2016	40.4	233.3
34	2017	40.4	233.3
35	2018	40.4	233.3
36	2019	40.4	233.3
TOTAL		1975.1	5031.7

Source: The Team



Source: "Port Development Policy", ESCAP Port Development Series No.6

Fig. 5.25 IMPACT OF PORT ON REGIONAL ECONOMY

5.3.3 Phuket Deep Seaport

1) Roles and Functions Required

As described in 5.3.1, Phuket Deep Seaport is situated very near to the international shipping route, only about 110 kilometers away from the route. The location is conductive to diversion of ocean going vessels to call Phuket Deep Seaport which has such base cargo as rubber and tin for export.

In contrast to Khanom Deep Seaport, Phuket Deep Seaport has very limited area adjacent to the port which restricts the functions of Phuket Deep Seaport. As described in 5.3.2 1), port has two major functions, namely, as a junction between sea and land transportation and a base for industrial activity. Because of land limitation, Phuket Deep Seaport cannot be a base for industrial activity but function as a base for international cargo distribution. Accumulation of urban functions and amenities as well as brisk activities of commerce, business and industy is one of the most indispensable factors that attract more international ship calls. From this viewpoint, Phuket is considered to have enough potential to be an international shipping center on the Andaman Sea Coast of the Malay Peninsula. In spite of the potential, however, it is rather difficult to be really an international commercial port because of fierce competitions among such ports as Penang, Kelang and Singapore Ports. Improvement of port facilities to accommodate full container vessels and port sales to shipping companies, consignors and public in general are examples for this kind of competition.

It would be reasonable to consider that Phuket Deep Seaport is an alternate commercial port to and from the western situated countries to Bangkok/Laem Chabang Ports, not only serving to its immediate hinterland but also to the whole country. In order to fulfil this function, it is a vital issue to develop inland transportation network with a special emphasis on direct linkage between the port and Bangkok, which will be achieved by railway extension from Khiri Ratthanikhom to the port. The availability of alternative route to and from the western situated countries will efficiently meet various transportation demand of product mixture in terms of timing and cost. In recent years, Thai manufactured or assembled televisions and radios, air conditioners and refrigerators, clothes and footwear, electronics and integrated circuits are finding profitable markets in the western situated countries. Phuket Deep Seaport supported with railway link is expected to contribute to promoting this tendency further in the future.

2) Phuket Deep Seaport in the Coastal Shipping Network

In the circumstances of competition with such international ports as Penang and Kelang, it would be a better way to concentrate investment on Phuket Deep Seaport so as to follow these preceding international ports. Though Krabi and Kantang Ports might be another candidate for international port, coexistence of plural international ports in the vicinity could not go well together.

Krabi is endowed with deep water level offshore to Ban Khlong Sai. At this moment, however, there is no accumulation of urban facilities and amenities to support an international commercial port in the nearby area. Good natural condition itself is an important factor to select the site of deep seaport but accumulation of trade activities established in the history is as important as natural condition to support international commercial port. In this regard, Kantang has a long history of international trading with the supporting city of Trang. However, Kantang Port is a typical riverine port to which ships have to travel a long channel of 27 kilometers to open sea, gearing to tidal fluctuations. The limiting depth in the channel of minus 2.5 meters and the rock over a short length appears to be a critical factor with respect to increased port utilization. Though both ports might have potentials to ship abundant mineral resources produced in their hinterlands, they have less opportunity than Phuket to be an international commercial port in the foreseeable future. Based on the above considerations, Krabi and Kantang Ports are better used as a feeder port to Phuket Deep Seaport as far as general cargoes are concerned.

As to the export of mineral resources, it is a common practice to prepare private jetties to accommodate international carriers for specific mineral resources. These carriers are operated on tramper basis in accordance with consignors' requests, resulting in a rather low operating rate of the jetty. Loading and unloading equipment required for mineral resources are different from those required for general cargo. From the viewpoint of port construction and maintenance, there is no necessity to integrate wharves for general cargo and jetties for mineral resources. More efficient way would be to allow/encourage development of private jetties for mineral resources at suitable locations with sufficient attention to environmental destruction because the improvement of riverine port necessitates huge amount of capital and maintenance dredging cost for accepting international carriers.

Phuket Deep Seaport should be used as a center port on the Andaman Sea Coast with such feeder ports as Krabi and Kantang. General cargoes for overseas market are to be forwarded from these ports to Phuket Deep Seaport, where they are transshipped to ocean going vessels.

3) Development Plan by the Fifth Five-Year Plan

The existing Port of Phuket is located at Khlong Tachin being three kilometers east of Phuket City. This port has small jetties for fishing boats on the both banks of the Khlong Tachin River and 50 meter long wooden pier used for container barges. Containers stuffed with rubber are transported by barge equipped with gear for loading on a feeder container vessel offing.

The feeder vessel takes the containers to Penang or Singapore for transshipment. A jetty exclusively used for Thaisarco is at Ao Makkham being seven kilometers south of Phuket City. The proposed new deep seaport of Phuket is scheduled to be constructed at Ao Makkham, north of Thaisarco's jetty. The first phase construction is composed of two berths with the length of 360 meters, wharf with the depth of minus 10 meters, channel dredging with 120 meter width and minus nine meter depth, and turning basin with a diameter of 360 meters. It is estimated that the site can accommodate a port development up to six berths. These features of the new port would make the port available to most of the world fleet of general cargo/part container ships and would allow first generation container vessels of approximately 15,000 DWT, 800 TEU (converted to 20 feet container) capacity to call.

4) Future Transportation Demand

Phuket Deep Seaport will be a sole gateway to the western situated countries facing to the Andaman Sea. The expected regular calling of ocean shipping can offer easy and timely access to world markets not only to the South but also to the whole country. Future transpor- tation demand related to Phuket Deep Seaport can be categorized into the following titles :

- Export of products produced in the hinterland.

- Direct import of specific cargoes needed in the hinterland.

- Direct shipment of general exports and imports of the country.

The first and the second titles are considered to be original purposes of the deep seaport construction. However, the third title should be paid more attention from the following aspects :

- Through the development of East-West Link, Phuket Deep Seaport is not an isolated port from Bangkok and other regions but connected directly with any other part of the country. This will greatly enhance the role of Phuket Deep Seaport as an alternative gateway to the western markets to Bangkok/Laem Chabang Ports.

- The government has been promoting special development strategies to diffuse growth and decentralize economic activities from Bangkok Metropolis to the other regions so as to reduce interregional and urban-rural disparities. This will bring about several economic activity centers of substantial magnitude scattered in the country. The availability of alternative export and import routes to and from the western market from these centers will efficiently meet their various transportation demand of product mixture from the viewpoint of cost and timing.

- Laem Chabang Port is planned and designed as the extension of Bangkok Port to overcome the constraints of the latter. In the long run, it will increase its importance as the main gateway to the country and Bangkok Port will then become a supplement of Laem Chabang Port. This transformation from Bangkok to Laem Chabang will considerably affect the import and export of the Western Region from the aspect of inland feeder transportation. Phuket Deep Seaport will become another prospective gateway to the western market for the Western Region.

Cargo handling volume of Phuket Deep Seaport in 2000 is estimated at 173,000 tons for coastal shipping and 859,000 to 1,253,000 tons for international shipping as shown in Table 5.18. Export from other regions via Phuket Deep Seaport is estimated on the assumptions that cargoes for export from Northern, Northeastern, Eastern and Central Regions and Bangkok Metropolis will be forwarded to Bangkok/ Laem Chabang Ports, and that exporting cargoes to the western situated countries from the Western Region will have a possibility to be forwarded to Phuket Deep Seaport. The future growth rate of export of the Western Region is based on the estimation by "Western Region Planning Study"; 2.5 percent under trend projection and five percent under trend and regional/national push policy.

Table 5.18 CARGO HANDLING VOLUME OF PHUKET DEEP SEAPORT IN 2000

Unit: 1,000 ton/year

Cargo	Domestic	Foreign	Total
Rubber	119	186	305
Palm Oil	54	109	163
Fishery Products	–	30	30
Tin	–	35	35
Others	–	163	163
Fertilizer	–	46	46
Export from Other Regions	–	290 - 684	290 - 684
Total	173	859 - 1,253	1,032 - 1,426

Source: The Team

According to the estimated transportation demand in 2000, four to five berths will become necessary for international shipping. After the completion of the first stage construction of two berths, future expansion should be studied in coordination with the subregional development of the Upper South and improvement/development of East-West Link.

5) Port Expansion Plan

To cope with the expected increase of cargo handling volume, an expansion plan of Phuket Deep Seaport was sketched based on the following viewpoints :

- To cover the first stage construction plan by the Fifth Five Year Plan

- To minimize the construction and maintenance costs as much as possible

- To prepare additional berths required for ocean going vessels of 15,000 DWT

- To provide berths for coastal shipping vessels including ferry boat to be operated between Phuket and Krabi and small crafts for port operation.

Port layouts for the first stage and for the year 2000 are as shown in Figures 5.26 and 5.27, respectively. New berths added to the first stage are two berths for ocean going vessels, two berths for coastal shipping vessels and one berth for ferry boat. Capital construction cost including cargo handling equipment and floating crafts is estimated at 1.4 billion baht, inclusive of cost for the first stage construction.

5.3.4 Kantang Port

1) Issue Regarding the Improvement of Kantang Port

Since the past Kantang has played a very important role as an entrance to Thailand from the Andaman Sea Coast. It is linked by railway with Nakhon Si Thammarat and the Lower South, and has thus expanded its hinterland as well as developed its facilities as a major port in this area. However, it was developed as a riverine port. Although this is quite reasonable under the then conditions of navigation dependent on small boats, but it has been increasingly difficult for the riverine port constrained by natural conditions to meet the recent advancement of navigation making frequent use of larger vessels.

The most crucial weakness is the channel of 27 kilometers which links the port and the mooring point. On average depth of minus three meters is available, but in one point at the bend depth is limited to minus 2.5 meters. Hence the size of vessel is limited to 300 tons and larger ships have to wait high water before navigating through the channel. In fact Maunsell Report in 1978 commented on this issue as follows:

The limiting depth in the channel of minus 2.5 meters and the "rock" over a short length appears to be a critical factor with respect to potential for increased port utilization. A proposal by Kampsax to realign the channel by cutting through Ko To Island has not been implemented, the suspected reason being the hard dredging encountered in this area. "Physical investigation including borehole drilling and seismic traversing" would be needed in this general area to determine the optimum channel location and to facilitate the application of suitable dredging plan according to the

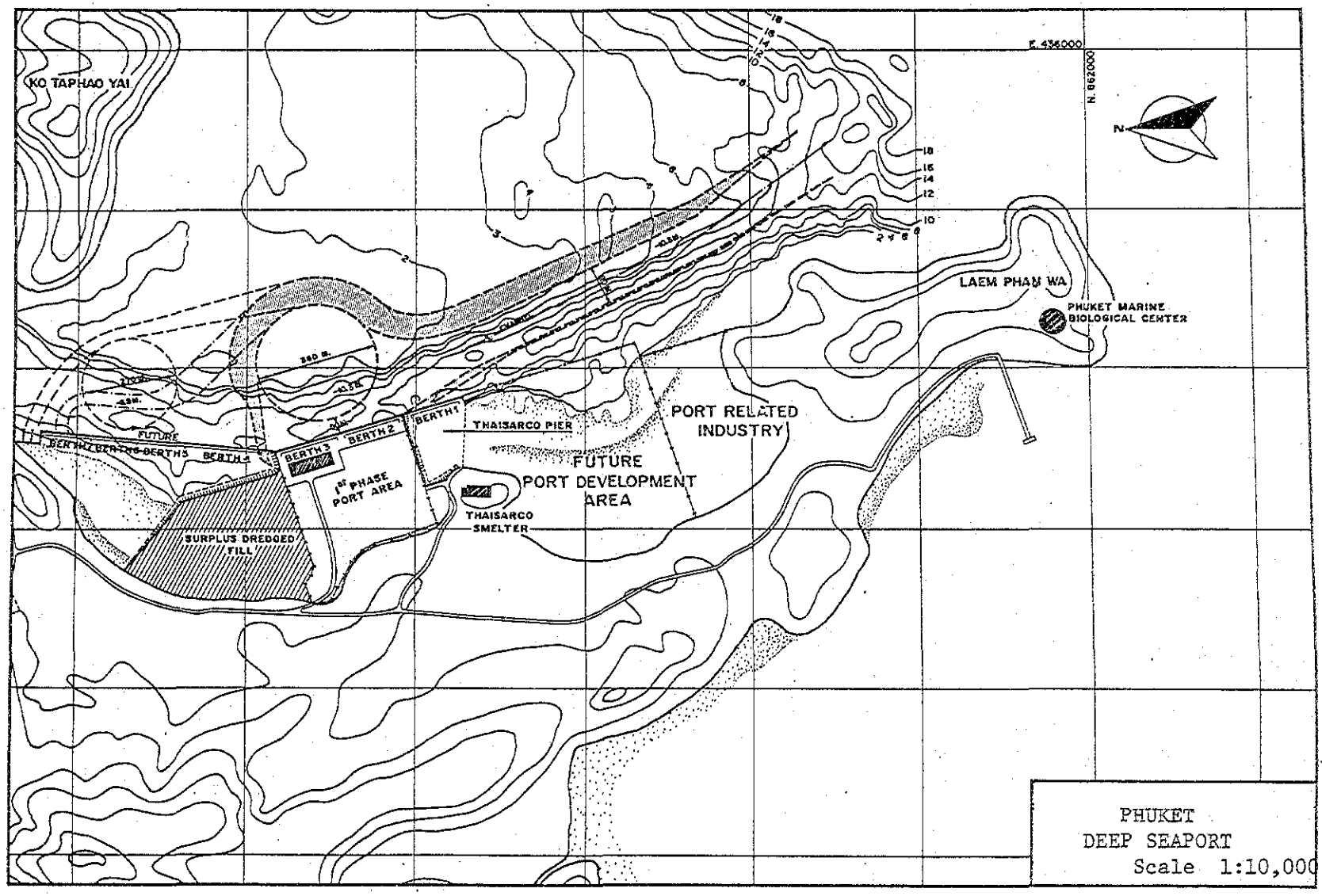


Fig. 5.26 PORT LAYOUT OF PHUKET DEEP SEAPORT FOR THE FIRST STAGE

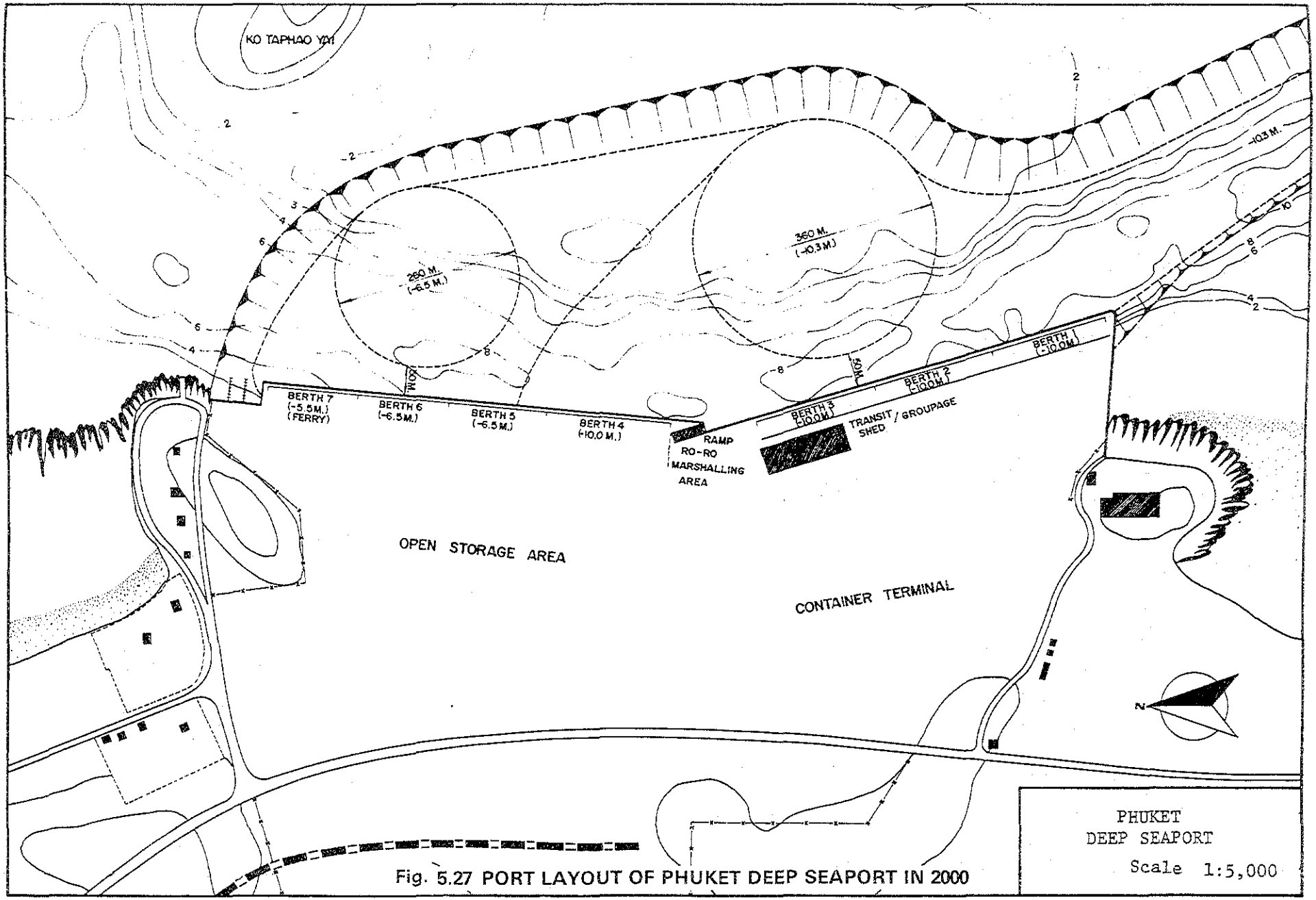


Fig. 5.27 PORT LAYOUT OF PHUKET DEEP SEAPORT IN 2000

"Coastal Ports Study" by Maunsell Consultants Ltd. In April, 1980 P.A.93.

Though some studies were conducted on the improvement of Kantang Port, any improvement has not been made for these 12 years since the completion of municipal pier, mainly due to the difficulties mentioned above.

According to the past customs record, major commodities handled at Kantang Port in recent years are as shown in Table 5.19 (years are picked up just to see the trend) :

Table 5.19 CARGO HANDLING VOLUME AT KANTANG PORT

Unit: 1,000 tons/year

	1974	1977	1981
Oil	27	34	73
Cement	119	72	2.5
Rubber	57	37	33
Fish landing	80	97	124
Other commodities	15	10	14.5
Total	298	250	247

Source: Statistics of Customs

Cargo handling volume at municipal pier excluding oil and fish landing which are handled at their private wharves shows a decreasing trend; 191,000 tons in 1974, 119,000 tons in 1977 and 50,000 tons in 1981. Though most of this decrease is caused by curtailment of cement export, this fact will indicate that Kantang Port has been deprived of its importance year by year due to the out-of-date facilities to meet the recent transportation demand. Stagnant port activity has resulted in reduced employment opportunity of people in Kantang District.

In view of the above described situations and the development strategy of the Upper South, improvement of Kantang Port is considered necessary to the extent that the vessel size of 600 to 1,000 DWT can navigate the channel to municipal pier. Through this improvement, Kantang Port can perform the following functions :

- In the long run, Kantang Port can play a role as a feeder port to Phuket Deep Seaport because this size of vessel is considered most efficient for coastal shipping. The effi-

ciency of the coastal shipping will be greatly reduced if it is dependent on the vessel size of 200 to 300 DWT.

- In the coming decade, Kantang Port can play a role as an international port supplementary to Phuket Deep Seaport. It will take about a decade that Phuket Deep Seaport can be a full-fledged international commercial port from the commencement of construction. Kantang Port is expected to substitute for Phuket Deep Seaport with its accumulated experience of international shipping. The maximum vessel size of about 3,000 DWT can navigate the channel by gearing to tidal fluctuations of the port.

- In very near future, it is expected that increased ship calls to Kantang Port will stimulate the economy of Kantang District. The restrictions that ships can not access to the port except for the period of high water spring prevent many ships from using the port. Elimination of this obstacle has certain effect of inviting more ship calls.

2) Improvement of Kantang Port

A detailed survey of the river and the 27 kilometer long access channel was made by "Kantang Port Study" by Kampsax in 1972 in order to find ways of reducing the costs of maintenance dredging. The target depth of the channel is four meters but the ruling depth is only about three meters. Many of the larger vessels must wait for the tide before negotiating the channel and this results in considerable loss of ship time.

It was recommended that the channel should be realigned, since the dredged channel at certain locations deviates from the natural river channel, and also because the scour effect of the river could be increased by the damming of some of the river branches. The major scheme would be the cutting of a new channel through Ko To where there is a very sharp S-curve. Another recommended improvement was the closure of the Stunt Channel between the Islands Kho and Laen, in order to eliminate the tendency to form shoals in the navigation channel.

Another major recommendation was that a sand trap should be dredged upstream of the port in order to catch sand brought down by the river before it is deposited in the navigation channel. Such a scheme would reduce the need for maintenance dredging considerably.

The final recommendation concerned the provision of navigation aids in order to help vessels negotiate the channel.

Through reviewing the report, we estimated rough project cost including repair cost of municipal pier as shown below :

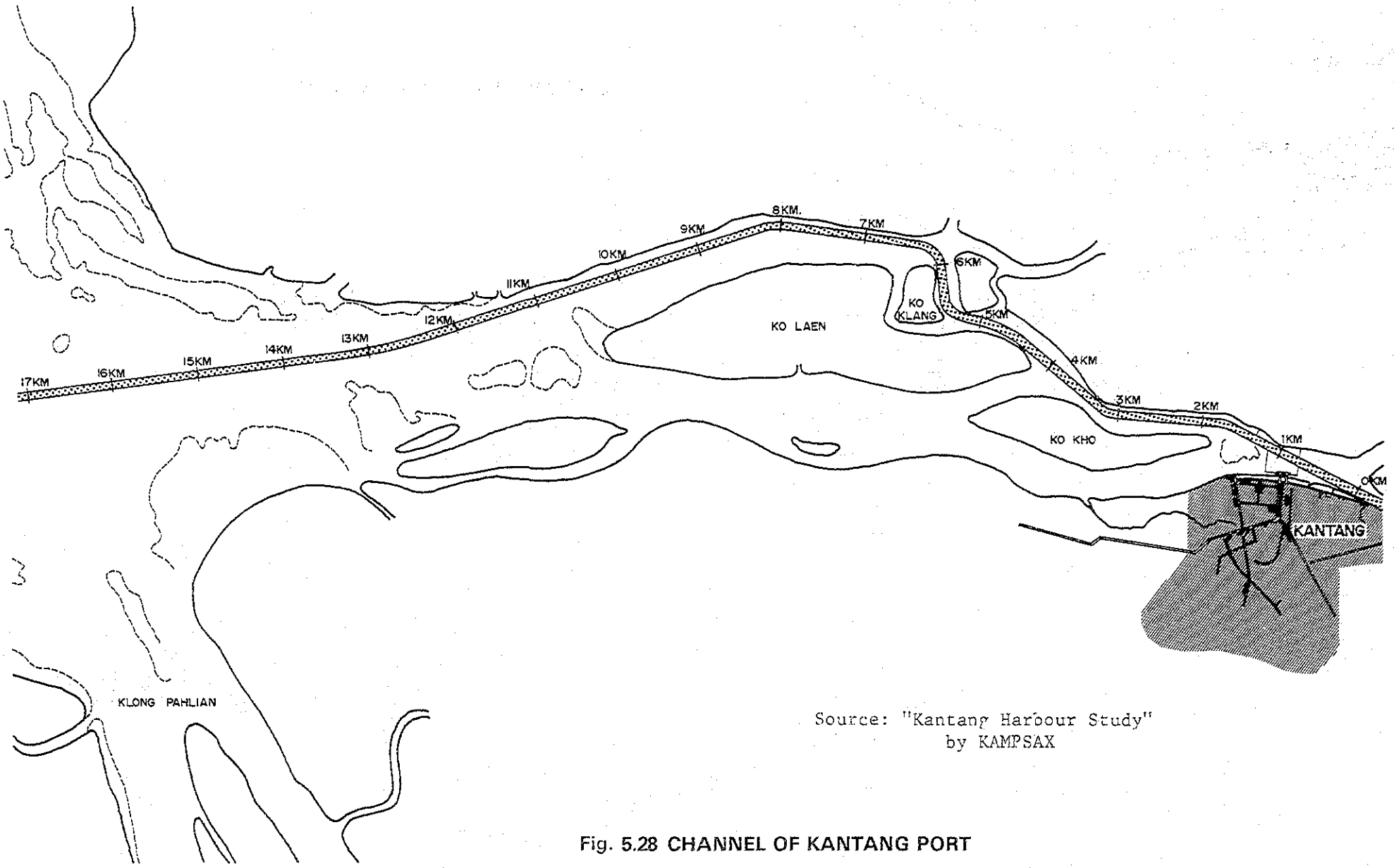
(1)	Survey and investigation	5.0 million baht
(2)	Cutting of a new channel (9 kilometers)	80.1
(3)	Navigation aids	2.0
(4)	Repair of municipal pier	1.5
	Total	88.6 million baht

Figures 5.28 and 5.29 shows the channel to Kantang Port.

In the re-estimation of the project cost, the closure of the Stunt Channel and a sand trap to be dredged upstream of the port are not included because we are not sure the effects of these measures at this moment. Detailed survey and investigation should be performed to confirm the effects of these measures as well as to get the data necessary for estimating the dredging quantity.

By these improvements, vessels of 600 DWT can negotiate the channel to municipal pier at anytime without waiting for high tide. The tidal range at Kantang Port is observed at plus 3.93 meters for high water springs, plus 2.23 meters for mean sea level and puls 0.53 meters for low water springs. Vessels of 3,000 DWT can negotiate the channel by gearing to the tidal fluctuations.

Immediate action will be very necessary for the improvement of Kantang Port in order to revitalize the economic activity of Kantang District including fishery development.



Source: "Kantang Harbour Study"
by KAMPSAX

Fig. 5.28 CHANNEL OF KANTANG PORT

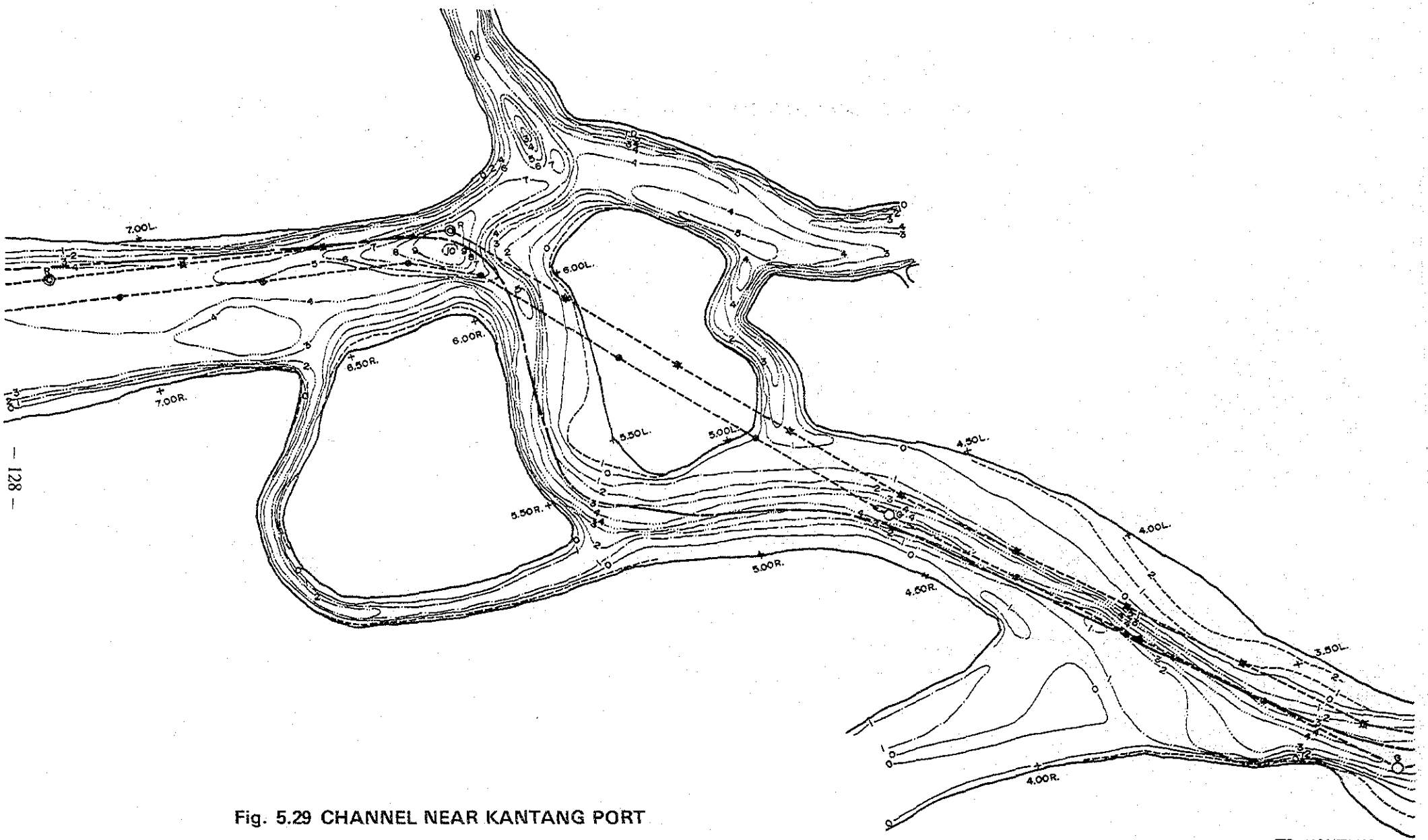


Fig. 5.29 CHANNEL NEAR KANTANG PORT

Source: "Kantang Harbour Study"
by KAMPSAX

6. CONDITIONS FOR IMPLEMENTATION

6.1 EAST-WEST ROAD LINK

The total length of East-West Road Link reaches 224 kilometers from Surat Thani to Phuket Deep Seaport, comprising of 10 sections as shown in Fig. 5.17. Though each section can have such specified functions to perform in their respective locations as additional access to urban area, agricultural development impetus to the area alongside, and substitution to an old bridge, the chain of these sections forms region-wide functions to connect the east and west coasts of the peninsula, thereby attaining better access to Phuket from Surat Thani/Bangkok. East-West Road Link should, therefore, be developed as a package of these sections.

Usually, development/improvement of national highways is budgeted section by section in accordance with the priority derived from field survey and economic analysis. From the viewpoint of subregional development of the Upper South, however, viability of East-West Road Link should be studied in the aggregate and the schedule of phased construction be worked out section by section based on economic, budgetary and construction capacity analyses.

On top of national and provincial highways under the jurisdiction of DOH, rural roads which give access to agricultural field, mining deposits and villages have been developed by provinces with the assistance of Public Works Department, Office for Accelerated Rural Development and so on. It is preferable to make good use of these roads for covering wider range of access to every part of the corridor area. East-West Road Link is required to promote development of the corridor area, especially such inaccessible area as Khiri Ratthanikhom and Ban Muang Mai.

Another aspect to be taken into consideration is to provide good access to candidate industrial sites and important transportation nodes. Along East-West Road Link, several candidate industrial sites are planned to be located, for instance, Surat Thani Industrial Estate, Phangnga Industrial Zone, Phuket Airport Industrial Estate and Phuket Small Industrial Zone. These industrial sites call for efficient transportation infrastructure to accept materials/labors and forward their products to market. It is necessary to provide well-suited linkages between the industrial sites and East-West Road Link. Along East-West Road Link, there are such important transportation nodes as Phuket Deep Seaport, Phuket and Surat Thani Airports and major railway stations. Taking into account that these transportation means can fully accomplish their functions only in combination with feeder road transport, appropriate linkages

between them should be established as well.

6.2 EAST-WEST RAIL LINK

The main function of East-West Rail Link is to connect the east and west coasts of the peninsula, providing direct access between Phuket and Bangkok. This rail link can perform its function by being connected to the Southern Main Line. This means that the efficiency of East-West Rail Link will be entirely dependent on the efficiency of the whole railway network.

As explained at the beginning of this report, railway was first modern breakthrough of inland transportation and kept its monopoly for several decades until highway network was extended to every part of the country. During the period of seller's market, supply of railway service was at the discretion of the State Railway of Thailand with little attention to the demands. In accordance with the development of highway network, however, the monopoly was gradually being collapsed and substantial part of the transportation demand shifted to road transport.

Though there are many factors that affect the choice of transportation means, speed is the most important one of all the factors. It takes 12 hours and 15 minutes from Bangkok to Surat Thani by express train, while it takes ten hours by bus. To cope with the competition, speed up of train operation is the most important issue to be tackled. Average running speed can be increased not only by improvement of facilities but also by improvement of softwares, such as

- reduction of time to spare,
- reduction of such waiting time as crossing, passing and connecting, and
- reduction of stations to stop.

Speed up can produce good results of reducing train hours which saves one of the biggest cost items of personnel expenses.

It is also a vital issue to supply flexible railway service to changing transportation needs. A person will have various criteria of choosing transportation means, depending on his occasion and destination. Express trains on the Southern Line is considered to be operated to connect Hat Yai with Bangkok. Departing and arriving schedule at Bangkok and Hat Yai is programmed in the daytime for the convenience of passengers. These express trains pass the area between Prachuap Khiri Khan and Surat Thani in the night time when feeder transportation means is not available there. To the contrary, buses are operated between Bangkok and every province in the South by more convenient schedule. To get the passengers back to railway, railway

service should be restructured to meet demands.

In recent five years, cargo transportation by railway showed a stagnated tendency. Though the reasons for this can be attributable to unfavorable competitiveness of railway in terms of speed and cost, the most decisive factor will be low reliability of railway trans- portation in terms of punctuality, damage and loss. Uncertainty of wagon preparation and no confirmation of arrival time to destination do not comply with the recent transportation demand because transportation is regarded as one of the whole process of production and sales management. Under the existing system, train hours stopping at stations/yards is longer than the train hours running on rail. Assortment operations at marshaling yard is supposedly the main reason for this uncertainty. To restore the competitiveness with road transport, it will be very necessary to develop an interregional rapid freight train system with no reliance on marshaling yard which extremely takes time and manpower. The number of cargo handling stations will necessarily be limited.

Unfavourable phenomena to railway usually appear firstly in cargo transportation and then the same phenomena prevail to passenger transportation. Every effort should be concentrated to overcome these problems by looking into changing market situations. Whether East-West Rail Link will be successful or not depends fairly on the competitiveness of the whole railway system with road transport, although the distance of 830 kilometers between Phuket and Bangkok warrants the superiority of railway to road transport.

Preliminary financial analysis of East-West Rail Link was performed to get the broad overview of profitability of the project. In case every cost is included, the Financial Internal Rate of Return (FIRR) is calculated at 3.6 percent. In case of excluding construction cost from the total cost, the FIRR is calculated at 11.7 percent. These results suggest that this project can be self-supporting if construction cost is subsidized by the government. Considering that this project associated with East-West Road Link is estimated to produce substantial benefit from the viewpoint of national economy, the subsidy from the government is indispensable to materialize the benefit. On the other hand, improvement of competitiveness and efficiency of the whole railway system should be pursued intensively for the better financial return from the project.

6.3 INTERNATIONAL PORT DEVELOPMENT

Ports of Thailand are composed of Bangkok Port which is the only one international port at this moment and small local ports which are used mainly for landing fishes and oil products and forwarding resources to transhipping ports. Based on this historical port structure, authorities for port construction and operation are consisted of Port Authority of Thailand which has the general responsibility for Bangkok Port, the Harbour Department which has the responsibility for construction and dredging of small local ports and local agencies which have operational responsibility of small local ports. In view of the consecutive programs of new international port construction, however, this institutional framework is considered inappropriate to tackle the coming port development, together with the lack of unified policy on port development.

In contrast to the past, the coming decade could be the crucially important for port development of the country. Four international port development works are expected to be implemented, namely, Laem Chabang Commercial Port, Map Ta Phut Industrial Port, Songkhla and Phuket Ports in the South. Laem Chabang Port is planned to overcome the natural and capacity constraints of Bangkok Port. Map Ta Phut Port is the first industrial port which supports the overall development of the Eastern Seaboard. Development of these two ports are promoted mainly from the national point of view. Songkhla and Phuket Ports will produce a great economic stimulus to the southern part of the country by providing direct linkage to the international market. Development of these two ports has different implication from that of the above two, placing a greater emphasis on regional development. Considering that some part of the export products from the South are presently forwarded to Penang for transshipment, port competition will become inevitable among the ports on the Malay Peninsula.

With the advent of diversified port development, the institutional framework for port administration should be transformed to cope with the new situations. The main fields requiring for restructuring port administration system can be enumerated as follows :

1) Specifying the roles of national and local port authorities

Though the major purpose of Bangkok and Laem Chabang Ports is to facilitate the interface between sea and land transport, greater importance will be placed on Songkhla and Phuket Ports for their regional development effects. In this conse-

quence, port authorities of Songkhla and Phuket are required to have both functions of efficient port administration and promotion of regional development. The roles of national and local port authorities should be clearly separated, the national port authority specialized in national port development policy and overall administration of all the ports and the local port authorities specialized in planning and management of a specified local port.

2) Integrating port construction and operation into an unified body

The ports to be newly developed have different characteristics depending on their expected functions. Port operations will differ each other, resulting in different requirement for hardware system and maintenance which should be in full accordance with utmost efficiency of port operation. In view of the above, port construction and operation bodies should better be integrated into an unified body.

3) Expanding the port area under the jurisdiction of port authority

In contrast to small local ports in the past, the ports to be newly developed would have conglomerated facilities in the adjacent area of port, for instance, industrial sites, warehouses, distribution centers/terminals, commercial zones and so on. In order to attain efficient interfaces among these facilities and prepare for the future expansion of the area in accordance with the programmed scheme, the area under the jurisdiction of port authority should not be limited only to wharf area but extended to the whole area identified by the scheme. This is an effective way to prevent environmental destruction as well.

4) Establishing well coordinated linkage between sea and land transport

In the anticipation of increasing container transportation for the international shipping, the new ports will be equipped with container handling facilities. For the smooth flow of container to and from port, however, the existing system should be reviewed taking into account that container transportation has been increased for bringing sealed containers from consignor to consignee with minimum documentation and time consumption. Well coordinated linkage between sea and land transport is essential to the efficiency of container transportation.

5) Promoting port sales activities

It is very important to introduce modern management system to port operation. Though modern management system pervades to every aspect of management, sales promotion would be most vital for newly developed ports. Even major international ports in the world have been deploying their sales activities to invite more ship calls to them. Port authorities should try their every effort to increase their cargo handling volume. Reasonable advertisement of the port and close contact with shipping companies/agents, domestic as well as international commerce and industry groups and other prospective customers could contribute greatly to improving the port image, informing the possible business chances and promoting a steady growth of the port.

These issues should be fully taken into account also for developing Phuket Deep Seaport and Khanom Deep Seaport.

7. TELECOMMUNICATIONS (TELEPHONE)

7.1 EXISTING SITUATIONS

Telephone services in terms of number of lines per 100 population in 1982 was one for the whole country, 5.5 for Bangkok Metropolis and 0.3 for provinces. Though telephone services are expanded at a very rapid pace, the country's economic and social development is progressing at a higher growth rate. In consequence, the expansion of telephone services fails to keep up with that of public demand for phones. Number of lines per public demand, which indicates the supply/demand situations of phones, is said to be 62 percent for the whole country, 63 percent for Bangkok Metropolis and 40 percent for provinces. Subscribers' complaints cover long phone-installation delays, temporally useless phones due to the insufficient channel capacity at peak hours, indirect international telephone call and noisy disturbances during conversations.

Direct dialling service is available for domestic long distance calls through the national center located in Bangkok. Four tertiary centers in Central, North, Northeast and South Regions are connected with Bangkok, through which long distance calls are transmitted to one another. Telephone network for the South is as shown in Figure 7.1. Capacity of the main line to the South is 5,400 channels up to Hua Hin, 3,600 channels to Thung Song and 1,800 channels to Yala. Switching stations in the South and the the Upper South consist of three levels of station:

- Secondary Station in the South
  Yala, Hat Yai, Thung Song, Phuket, Phun Phin (Tertiary)

- Primary Station in the the Upper South
  Surat Thani, Phangnga, Phuket, Krabi

- Local Station in the the Upper South
  (Surat Thani) Surat Thani, Phun Phin, Chaiya and Ban Na San
  (Phangnga) Phangnga, Takua Pa
  (Krabi) Krabi

Capacity of the branch line connecting secondary station with primary station is composed of 300 channels and that of the end-section line connecting primary station with local station is composed of 120 channels.

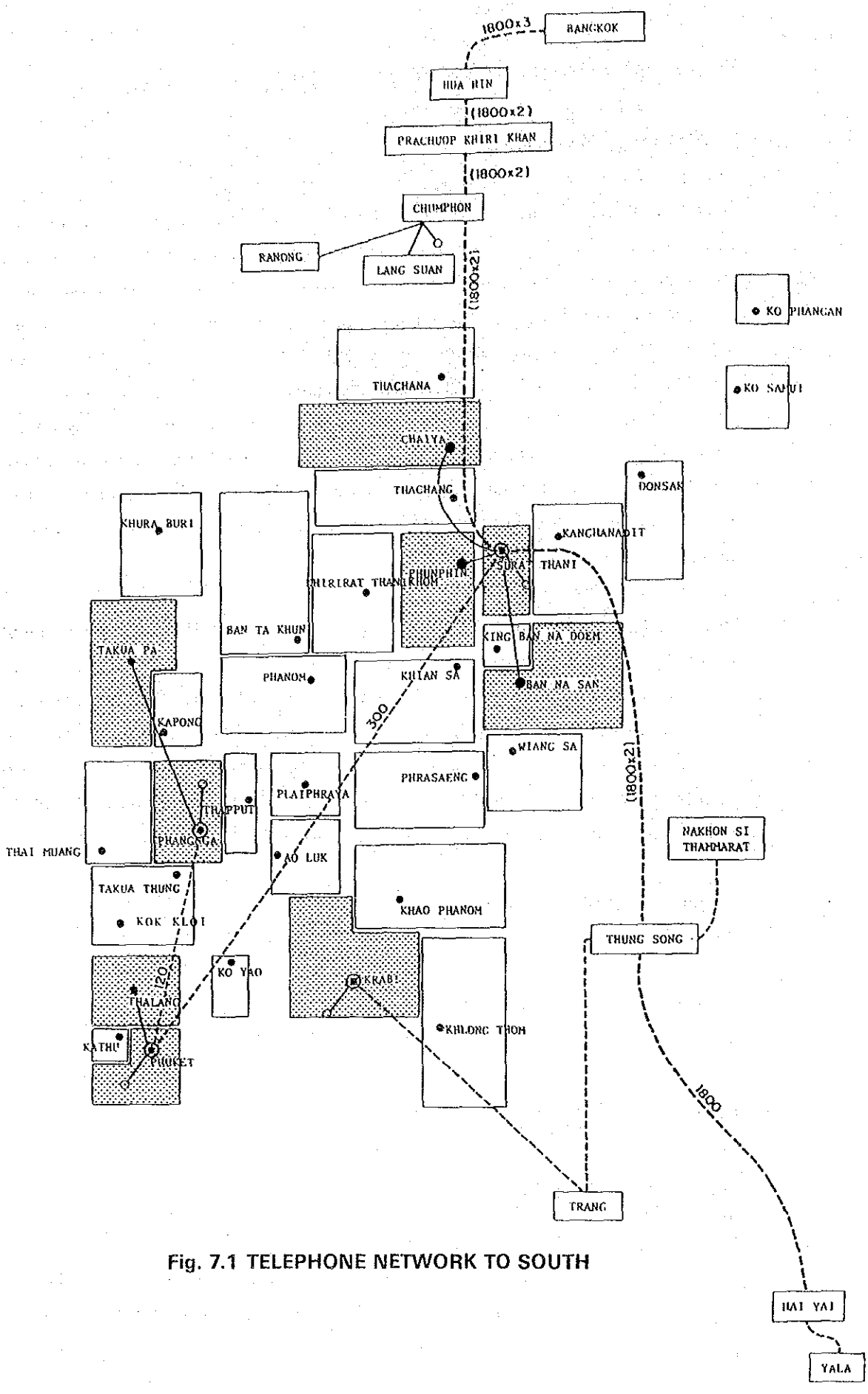


Fig. 7.1 TELEPHONE NETWORK TO SOUTH

Supply/demand situations of telephone services in the the Upper South is as shown in Table 7.1. Number of lines per public demand is 48 percent for the the Upper South; 62 percent for Surat Thani, 32 percent for Phangnga, 42 percent for Phuket and 39 percent for Krabi. Though there are some differences among provinces, public demand for phones is barely satisfied at a level of 50 percent in the area accessible to telephone services. Applicants for telephone services are classified into two groups according to a priority list prepared by Telephone Organization of Thailand (TOT); a group with no/less waiting for the installation and another group with long waiting. Private companies without promotion priviledges by Board of Investments and households in general belong to the second group.

Table 7.1 SUPPLY/DEMAND OF TELEPHONE SERVICES IN UPPER SOUTH

	(1) Line Capacity (No.)	(2) Main Tel. Station (No.)	(3) Waiting (No.)	(4) Required No. of Subscriber	(5) Ratio (1)/(4) (%)
Upper South	6,200	5,359	7,627	12,986	48
Surat Thani (077)	3,000	2,248	2,594	4,842	62
– Surat Thani	2,000	1,323	2,041	3,364	59
– Phun Phin	600	540	99	639	94
– Chaiya	200	191	67	258	76
– Ban Na San	200	194	387	581	34
Phangnga (076)	600	569	1,285	1,854	32
– Phangnga	400	370	33	403	99
– Takua Pa	200	199	1,252	1,451	14
Phuket (076)	2,200	2,142	3,124	5,266	42
– Phuket	2,000	1,958	2,826	4,784	42
– Thalang	200	184	298	482	41
Krabi (075)	400	400	624	1,024	39

Note: 075 Area Code for Thung Song
076 Area Code for Phuket
077 Area Code for Phun Phin

Source: Telephone Statistics 1982 by TOT

The coverage zones of telephone services in the the Upper South are usually within a radius of five kilometers from the nine local stations. The area accessible to telephone services is roughly estimated at 3.2 percent of the whole are of the the Upper South. Applicants from remote area outside TOT's coverage zone are forced to install VHF radio transmission system at their own cost under the jurisdication of TOT. Private companies as well as households in general have to bear the installation cost of about 200,000 baht.

The present problems of telephone services in the the Upper South can be itemized as follows:

- Long waiting for telephone installation due to chronic shortage of exchange capacity.

- Long and indefinite waiting for long distance calls due to shortage of traffic capacity (channels) in peak hours.

- Limited accessibility to telephone services due to underdevelopment of network.

7.2 DEVELOPMENT PROGRAMS

The Economic Development Project (EDP) of TOT 1984 - 1988 aims to achieve the following four objectives:

- To expand the line capacity in areas already serviced so as to meet demand, and to extend the service into new rural communities up to subdistrict level.

- To raise the standard of services by improving existing services and introducing new ones.

- To increase the network's strength and capacity in line with the country's development policy to comply with the increasing long distance traffic.

- To expand the public telephone services so as to meet demand, especially in tourist areas.

The EDP calls for the extension of local telephone services as shown in Table 7.2. The line capacity of the country is planned to be increased from 500,000 in 1982 to 1,951,000 in 1988. At the end of the project period, the line capacity is expected to

reach 1,193,000 in Bangkok Metropolis and 758,000 in provinces. The composition ratio of the line capacity of provinces will be raised from 31 percent in 1982 to 39 percent in 1988, the expansion rate being 30 percent per annum. The line capacity in the South is scheduled to increase from 25,700 in 1982 to 138,000 in 1988.

Table 7.2 ECONOMIC DEVELOPMENT PROJECT OF TOT 1984-1988 (NUMBER OF LINE CAPACITY TO BE ADDED)

	Line Capacity 30/9/1982	After EDP 1977 - 1984	Add in EDP 1984 - 1988	Total Lines After EDP 84 - 88
Whole Country	499,663 (100.0)	997,959 (100.0)	953,522	1,951,481 (100.0)
Metropolitan	345,428 (69.1)	660,800 (66.2)	532,520	1,193,320 (61.1)
Provincial	154,235 (30.9)	337,159 (33.8)	421,002	758,161 (38.9)
North	27,478 (5.5)	77,971 (7.8)	99,410	177,381 (9.1)
Northeast	30,582 (6.1)	71,191 (7.1)	120,032	191,223 (9.8)
Central	70,473 (14.1)	123,641 (12.4)	127,978	251,619 (12.9)
South	25,700 (5.1)	64,356 (6.4)	73,582	137,938 (7.1)

Note: 1) EDP stands for the Economic Development Project of TOT
2) ( ) indicates a composition ratio in percentage

Source: TOT

It is planned for the the Upper South that the area accessible to telephone services will be expanded from nine districts to all the districts as shown in Table 7.3 and Fig. 7.2. The total line capacity is to be increased from 6,200 in 1982 to 44,500 in 1988, at an expansion rate of 39 percent per annum. The line capacity for the area accessible to telephone services at present will amount to 31,300 while the telephone services to new rural communities will amount to 13,200. The coverage zone of telephone services in the the Upper South is roughly estimated at 14 percent of the whole area of the the Upper South on the assumption of five kilometers radius for each coverage zone.

On top of the above mentioned expansion of telephone services, the EDP plans to improve the quality of telephone services. The promotion of installing Stored Program Control (SPC) Digital Switching Equipment will greatly help transmit various kind of information on the same communication network as illustrated in Figure 7.3. In conventional communication system, different kind of network is required for telephone services, telex services, data transmission services and so on. These different kind of information, however, can be transmitted simultaneously through inhouse connector to digital network.

Table 7.3 ECONOMIC DEVELOPMENT PROJECT OF TOT 1984-1988

Unit: Number of lines

	Line Capacity 30/9/1982	After EDP 1977-1984	Add in EDP 1984-1988 Lines Date	Total Lines After EDP 84-88
Surat Thani	3,000	6,800	12,378	19,178
Surat Thani	2,000	4,000	5,618 OCT 86	9,618
Phun Phin	600	800	1,024 OCT 86	1,824
Ko Samui	–	600	400 OCT 86	1,000
Chaiya	200	400	600 JAN 88	1,000
Ban Na San	200	1,000	512 APR 87	1,512
Khian Sa	–	–	128 SEP 87	128
Pharasaeng	–	–	256 NOV 87	256
Wiang Sa	–	–	1,024 JUN 87	1,024
Khiri Ratthanikhom	–	–	256 DEC 87	256
Phanom	–	–	128 FEB 88	128
Tha Chang	–	–	512 DEC 86	512
Don Sak	–	–	512 AUG 87	512
Ban Ta Khun	–	–	128 JAN 88	128
Ban Na Doem	–	–	256 OCT 87	256
Tha Chana	–	–	512 FEB 87	512
Kanchanadit	–	–	256 MAR 88	256
Ko Phangan	–	–	128 APR 88	128
Chai Buri	–	–	128 MAY 88	128
Phangnga	600	2,600	5,376	7,976
Phangnga	400	600	400 MAR 86	1,000
Khapong	–	–	256 AUG 86	256
Ko Yao	–	–	512 MAY 86	512
Khura Buri	–	–	512 JUL 86	512
Takua Thung	–	–	512 NOV 86	512
Takua Pa	200	2,000	1,072 APR 86	3,072
Thap Put	–	–	512 JUL 86	512
Thai Muang	–	–	600 SEP 86	600
Khok Kloi	–	–	1,000 JAN 87	1,000
Phuket	2,200	7,000	6,672	13,672
Phuket	2,000	6,000	4,272 MAR 86	10,272
Thalang	200	400	600 APR 86	1,000
Krathu	–	600	400 JUN 86	1,000
Chalong	–	–	1,000 AUG 86	1,000
Ao Makkham	–	–	400 OCT 86	400
Krabi	400	2,000	1,664	3,664
Krabi	400	2,000	0 –	2,000
Ao Luk	–	–	512 MAY 87	512
Khao Phanom	–	–	128 SEP 87	128
Plai Phraya	–	–	128 OCT 87	128
Ko Lanta	–	–	128 NOV 87	128
Khlong Thom	–	–	256 AUG 87	256
Nua Khlong	–	–	512 JUL 87	512
Study Area Total	6,200	18,400	26,090	44,490

Source: TOT

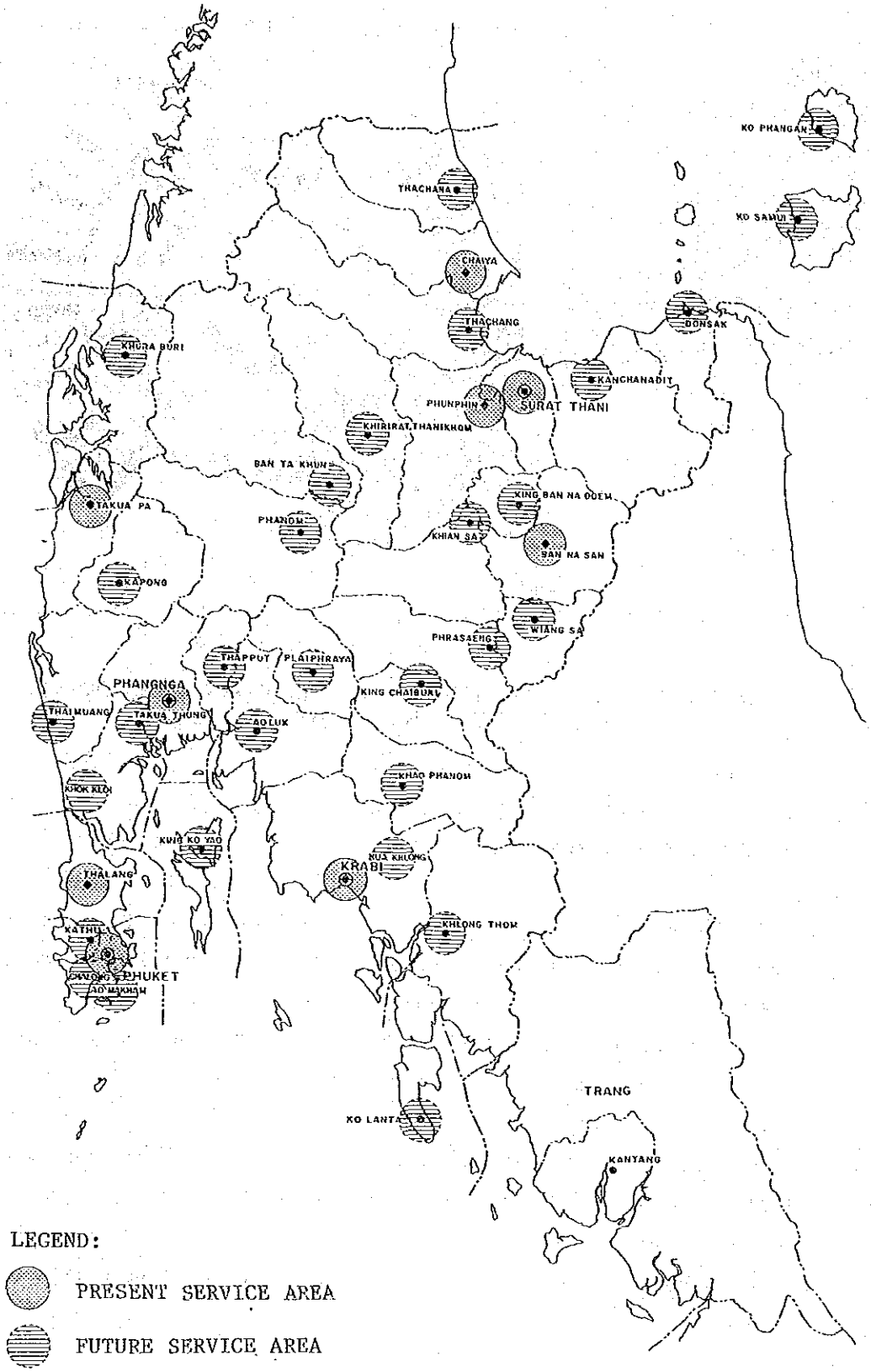


Fig. 7.2 TELEPHONE SERVICE AREA IN UPPER SOUTH BY 1988

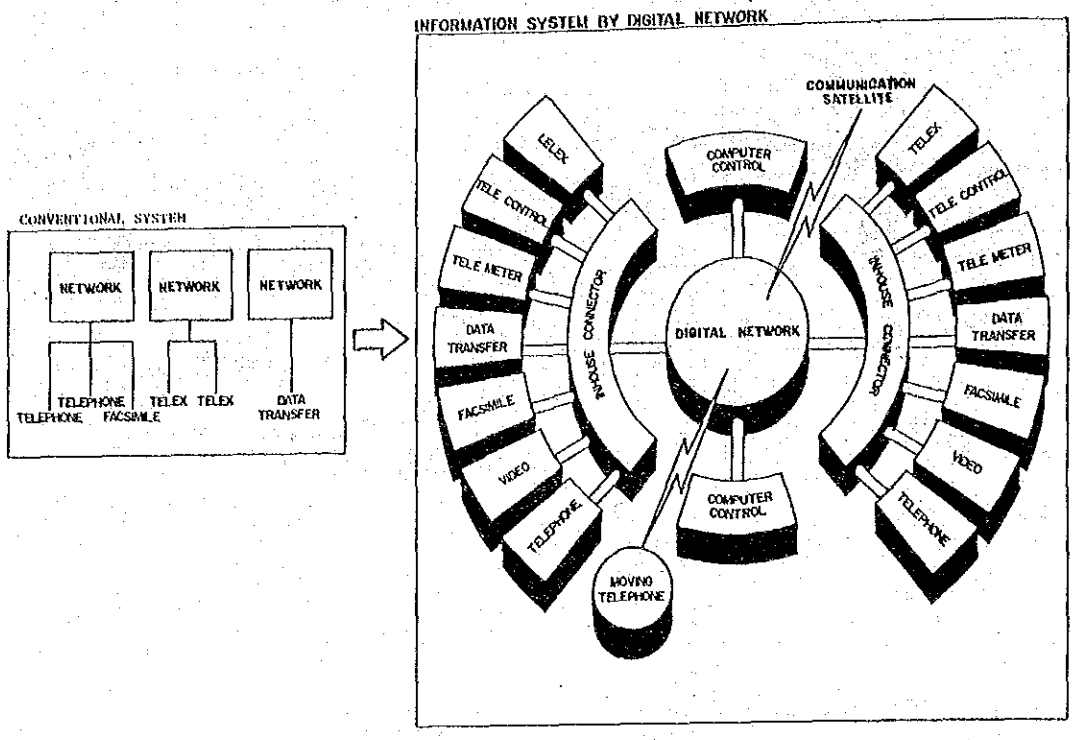


Fig. 7.3 COMPARISON BETWEEN CONVENTIONAL SYSTEM AND DIGITAL NETWORK SYSTEM

7.3 FUTURE REQUIREMENT

EDP 1984 to 1988 is expected to improve the telephone services to a great extent in terms of number of lines per 100 population (to be 3.2) and the area accessible to telephone services. To attain these goals, however, the project's operating budget amounts to about 37,460 million baht comprising 18,380 million baht in local currency and 19,080 million baht in foreign currencies. Funds will come from TOT revenue and subscribers' deposits, amounting to 3,630 million baht; telephone bonds and miscellaneous sources, 6,415 million baht; and increase in TOT funds other than loans, 8,335 million baht. Without budgetary cooperation from government, success of EDP entirely depends on TOT's ability to raise fund. The TOT's privatization policy is one of the steps to mobilize funds which will allow for the rapid expansion of services.

From the viewpoint of regional development, further emphasis should be given to the expansion of network's strength and capacity in the succeeding EDPs. Among various factors affecting industrial locations, availability of easy access to information sources is one of the most important factors. Development of efficient international

communication channels has another importance in the face of accelerating internationalization. The the Upper South is expected to be developed primarily through dependence on tourism business and manufacturing industries based on its abundant local resources. Tourism business will generate multi-directional telephone services, internationally, regionally and locally. Manufacturing industries require real time access to international marketing information, especially for such international products as rubber, palm oil and tin. For longer perspectives, the the Upper South is expected to be a base to accept relocation of industries now concentrated in Bangkok Metropolis. No waiting time for long distance calls to and from Bangkok is the most essential factor to accelerate the trend. Special attention should be paid to increase the network's capacity in peak hours. The improvement of communication network will contribute to resettling the people required for such industries, too.

In spite of these requirements for the development of the the Upper South, expansion of telephone services should be pursued in line with the EDP 1984 to 1988, taking account of the quite low rate of telephone services in provinces all over the country. The better way to cope with regional development requirements is to prepare a master plan in longer perspective, with full consideration into every regional development plan. During the course, efforts should be made to improve the mobilization of funds which allow for rapid expansion of services, the managerial ability to implement such ambitious investment programs on schedule, and closer coordination between TOT and Communications Authority of Thailand to expand the telex and international telephone services.

ANNEX

CONTENTS

TABLES

FIGURES

ANNEX I TERMS OF REFERENCE FOR PROPOSED FEASIBILITY STUDIES

1. TERMS OF REFERENCE FOR FEASIBILITY STUDY ON EAST-WEST ROAD LINK CONNECTING PHUKET AND SURAT THANI (DRAFT)

A. BACKGROUND

The Upper South (Surat Thani - Phuket Zone) is designated as a specific area development zone based on the locational advantages as well as resource potentials. Phuket is an alternative gateway to the western situated countries, facing directly to the Andaman Sea. The cumulated trading functions coupled with internationally-minded entreprenuership will surely make it possible for Phuket to be an international gateway to the west. Surat Thani is expected to be a subregional center of industry, distribution and urban functions on the coast of the Gulf of Thailand. Easy access of Surat Thani to Eastern Seaboard provides it with a great opportunity to be linked with a seaboard industrial development along the coast of the Gulf of Thailand. In this context, it is the most strategic issue to develop transportation network linking the Phuket and Andaman coastal economy more closely with the mainstay of the national economy being in Bangkok and unifying the Phuket and Surat Thani economies more closely to each other. "The Subregional Development Study of the Upper Southern Part of Thailand" (by JICA in April 1985) proposes to develop the East-West Link connecting Phuket with Surat Thani in a phased manner; firstly by Road Link and secondly by Rail Link. East-West Road Link is expected to improve the accessibility to Phuket Deep Seaport from the immediate hinterland and to reduce the travelling time between Phuket and Surat Thani. On the other hand, East-West Rail Link is expected to provide efficient transportation means to Phuket Deep Seaport from Bangkok and other regions. The study proposes to construct a new bridge connecting the Phuket Island with the main land to accommodate both Road Link and Rail Link, as a part of East-West Link. Consultants are required to have full understanding of the subregional development scenario, ranging from overall development strategy of the Upper South to time-phasing of each project and program of the Upper South development.

B. OBJECTIVES

The basic objective of the study is to conduct the engineering and economic feasibility study on East-West Road Link for the whole section between Phuket Deep Seaport and Surat Thani City.
A prototype East-West Road Link is scheduled to be completed by the end of the Fifth Five-Year Plan period, and further improvements are planned in the following Five-Year Plan. These improvement programs as well as periodic maintenance works should fully be incorporated into the development of East-West Road Link. Alternative alignments should be studied from the viewpoint of minimizing investment cost and travelling time distance between

Phuket and Surat Thani, and maximizing the development effect on the corridor area. Based on the study, some alternative routes should be prepared for further comparative studies. It is also necessary to work out some alternatives of Phuket New Bridge which is planned also as a tourism symbol of the island.
During the course of the study, it is very important to take account of the relationship of East-West Road Link with East-West Rail Link. Though the major roles and functions of Road Link and Rail Link are different, these two links are innevitably competitive with each other. It is required to propose efficient truck transportation system between the Upper South and Bangkok. Economic viability should be assessed in terms of internal rate of return, net present value and benefit cost ratio. Each alternative should be examined of its viability for different sets of construction phasing. Through these economic analyses, the most economical development phasing for the project should be worked out.

C. SCOPE OF WORK

1) General

The study shall be conducted in two phases:
(1) Phase I
(2) Phase II

(1) Phase I shall consists of review of the subregional development study of the Upper South, economic and traffic data collection, origin and destination survey, other supplementary traffic survey, preliminary cost estimates and, based on traffic projections and preliminary economic analyses for each of the various alternatives under study, recommendations for typical cross-sections, design speeds, design standards and alignment location. The objective of phase I study is to permit the selection of the most appropriate alternative alignment for further study on the basis of preliminary economic analyses.

(2) Phase II shall consist of more detailed field surveys, preliminary engineering, refined cost estimates and final economic and financial analyses to complete the feasibility study of the proposed project on the basis of recommendations by the phase I study.

The Consultants should fully understand the subregional development master plan of the Upper South, particularly during the phase I period; overall development concept of the Upper South, intersectional relationship, competitive as well as complementary relationship between road and railway transport, time phasing of projects and programs, and so forth. Development of East-West Road Link should have close conformity with the subregional development master plan.

2) Alignment Selection

Based on a review of the prefeasibility study of East-West Link, available maps and aerial photographs taken for this purpose, the Consultants shall investigate all important alternative alignments and design standards, and conduct reconnaissance field surveys to the extent necessary for preliminary layout and cost estimates of each alternative alignment.
The cost estimates shall be based on the construction costs per kilometer of highway calculated for typical sections in various types of terrain, for the design and construction standards best suited to serve the terrain and the anticipated traffic on each highway section.
In addition, the Consultants shall identify, describe, and quantify existing and probable future traffic generating sources, based on the subregional development master plan of the Upper South, including;

(1) Development of manufacturing and processing industries in the Upper South; and
(2) Probable timing for implementation and economic impact of the construction of road and railway projects over the Upper South.

In forecasting traffic on East-West Road Link, the Consultants shall take into account fully the interaction between road and rail transportation.
The Consultants shall make preliminary economic analyses for each of the alternative alignments and design standards, and for an appropriate range of design possibilities and implementation stages. On this basis, the Consultants shall make recommendations as to the best alignment, design and construction standards, right-of-way, and recommend stages of construction, if necessary, for appropriate sections of East-West Road Link taking into account traffic requirements and the economic viability of its proposed construction work for the corresponding sections.

3) Preliminary Engineering

After review and approval by the Government, the Consultants shall prepare preliminary engineering designs for East-West Road Link. Preliminary engineering for these studies shall be carried out to a degree of accuracy that will permit estimates of principal quantities of construction with an accuracy of 20 percent. The principal quantities of construction shall include common excavation, rock excavation subbase material, base and surfacing materials, number and size of drainage structures, major bridges, and other structures. Preliminary engineering design of major bridges and other major structures shall include determination of the spans, types of super-structures and types of foundations including necessary subsurface explorations. Phuket New Bridge is to be tourism symbol of the Phuket Island, and the area is planned to be a tourism development zone, too. This bridge should be designed in this context, for accommodating both two-lane highway and single track railway.

The Consultants shall undertake all necessary field investigations including necessary soils survey, to determine principal quantities of excavation and construction, prepare the preliminary engineering designs, and locate suitable sources of materials. On the basis of these field surveys, the Consultants shall estimate the construction cost of East-West Road Link. Unit prices for each item of work shall be broken down into basic cost elements (labor, materials, equipment, tools, taxes, overhead cost and profit). Items for acquisition of right-of-way, physical contingencies, consultant's final engineering fee and supervision fee, and possible escalation of unit costs between feasibility study and final construction shall be provided separately.
The Consultants shall identify the components of foreign and local currency for all proposed construction.

The foreign currency component shall include both the direct and indirect foreign currency requirements for the Project. The direct foreign exchange component shall include such items as equipment depreciation, materials and supplies of which Thailand is a net importer, wages of foreign personnel, overhead cost and profit of foreign firms. The indirect foreign exchange component is the import content of locally produced items. The local currency component covers the domestic content of locally produced materials and supplies, local salaries and wages, etc. Provisions for taxes, import duties, etc. will be shown separately. These cost estimates shall be used in a second analysis of East-West Road Link.
The Consultants shall also assess the availability and capacity of domestic contractors who would be in a position to undertake the proposed project, and provide a list of construction equipment required for the project construction.

4) Economic Analysis

The economic analysis of East-West Road Link shall be based on the followings:

(1) Estimates of transport costs on highways (using unit costs of owning and operating typical vehicles on existing roads and proposed highway);

(2) Estimated costs of road operation including maintenance on existing and projected highways;

(3) A comparison of the expected economic costs of construction and incremental maintenance and administration costs with the savings estimated in (1) above, for the period of analysis of the proposed highway, for computations of the internal rate of return on the investments;

(4) A sensitivity analysis of the internal rate of return for possible variations in major assumptions made in the estimation of economic costs and benefits;

(5) The identification to the extent possible of unquantifiable economic benefits of the Project and of the anticipated social and environmental impact of the proposed program and an assessment of its importance to the country and the Region influenced by the Project.

Economic justifications shall be provided separately for each alternative alignment.

D. STAFFING

The study team shall consists of experts at least in the following fields;

(1) Project management

(2) Regional economic analysis

(3) Transport planning

(4) Landuse

(5) Highway planning, design and construction

(6) Structural design and construction

(7) Bridge engineering

(8) Cost estimation

(9) Economic and financial analysis

(10) Material and geotechnical analysis

(11) Hydraulic analysis

2. TERMS OF REFERENCE FOR FEASIBILITY STUDY ON EAST-WEST RAIL LINK CONNECTING PHUKET AND SURAT THANI (DRAFT)

A. BACKGROUND

The Upper South (Surat Thani-Phuket Zone) is designated as a specific area development zone based on the locational advantages as well as resources potentials. Phuket is an alternative gateway to the western situated countries, facing directly to the Andaman Sea. The cumulated trading functions coupled with internationally-minded entreprenuership will surely make it possible for Phuket to be an international gateway to the west. Surat Thani is expected to be a subregional center of industry, distribution and urban functions on the coast of the Gulf of Thailand. Easy access of Surat Thani to Eastern Seaboard provides it with a great opportunity to be linked with a seaboard industrial development along of the coast of the Gulf of Thailand. In this context, it is the most strategic issue to develop transportation network linking the Phuket and Andaman coastal economy more closely with the mainstay of the national economy being in Bangkok and unifying the Phuket and Surat Thani economies more closely to each other. "The Subregional Development Study of the Upper Southern Part of Thailand" (by JICA in April 1985) proposes to develop the East-West Link connecting Phuket with Surat Thani in a phased manner; firstly by Road Link and secondly by Rail Link. East-West Road Link is expected to improve the accessibility to Phuket Deep Seaport from the immediate hinterland and to reduce the travelling time between Phuket and Surat Thani. On the other hand, East-West Rail Link is expected to provide efficient transportation means to Phuket Deep Seaport from Bangkok and other regions. The study proposes to construct a new bridge connecting the Phuket Island with the main land to accommodate both Road Link and Rail Link, as a part of East-West Link. Consultants are required to have full understanding of the subregional development scenario, ranging from overall development strategy of the Upper South to time-phasing of each project and program of the Upper South development.

B. OBJECTIVES

The basic objective of the study is to conduct the engineering and economic feasibility study on East-West Rail Link for the whole section between Phuket Deep Seaport and Ban Thung Pho Junction of the Southern Line. The Southern Line is scheduled to be improved during the Fifth Five-Year Plan period for attaining a higher speed of train operation. The existing Khiri Ratthanikhon Stur Line can be made use of for the East-West Rail Link. These existing facilities and programmed improvements should be fully made use of for the development of East-West Rail Link. For the new construction section, alternative alignments should be studied from the viewpoint of minimizing investment cost and travelling time distance between Phuket Deep Seaport and the Southern Line,

and maximizing the possible development effect on the corridor area. Based on the study, some alternative routes should be prepared for further comparative study. It is, however, very important to coordinate the alignment with that of East-West Road Link, especially for Phuket New Bridge and the alignment on the Phuket Island. As described already, the main function of East-West Rail Link is to ensure the efficient long haul transportation between Phuket Deep Seaport and Bangkok/Other regions. This implies that the efficiency of East-West Rail Link is entirely dependent on the efficiency of the whole railway network. It is another requirement to propose a new operating and management system of railway so as to improve its competitiveness with truck transport, particularly for the Southern Line. Economic viability should be assessed in terms of internal rate of return, net present value and benefit cost ratio. Financial viability should also be investigated for the possible sets of railway fare and financial source. Through these economic as well as financial studies of the project, the best timing of the implementation should be worked out in close coordination with the development of East-West Road Link.

C. SCOPE OF WORK

1) General

The study shall be conducted in two phases:

(1) Phase I
(2) Phase II

(1) Phase I shall consists of review of the subregional development study of the Upper South, economic and traffic data collection, origin and destination survey, other supplementary traffic survey, preliminary cost estimates and, based on traffic projections and preliminary economic analyses for each of the various alternatives under study, recommendations for typical cross-sections, design speeds, design standards and alignment location. The objective of phase I study is to permit the selection of the most appropriate alternative alignment for further study on the basis of preliminary economic analyses.

(2) Phase II shall consist of more detailed field surveys, preliminary engineering, refined cost estimates and final economic and financial analyses to complete the feasibility study of the proposed project on the basis of recommendations by the phase I study.

The Consultants should fully understand the subregional development master plan of the Upper South, particularly during the phase I study period; overall development concept of the Upper South, intersectional relationship among sectors, competitive as well as complementary relationship between road and railway transport, time phasing of projects and programs, and so forth.

Development of East-West Rail Link should have close coordination with that of East-West Road Link in the full context of the subregional development master plan.

2) Alignment Selection

Based on a review of the prefeasibility study of East-West Link, available maps and aerial photographs taken for this purpose, the Consultants shall investigate all important alternative alignments and design standards, and conduct reconnaissance field surveys to the extent necessary for preliminary layout and cost estimates of each alternative alignment.
The cost estimates shall be based on the construction costs per kilometer of railway calculated for typical sections in various types of terrain, for the design and construction standards best suited to serve the terrain and the anticipated traffic on each railway section.
In addition, the Consultants shall identify, describe, and quantify existing and probable future traffic generating sources, based on the subregional development master plan of the Upper South, including;

(1) Development of manufacturing and processing industries in the study area; and

(2) Probable timing for implementation and economic impact of the construction of road and railway projects in the Upper South.

In forecasting traffic on East-West Rail Link, the Consultants shall take into account fully the interaction between road and rail transportation.
The Consultants shall make preliminary economic analyses for each of the alternative alignments and design standards, and for an appropriate range of design possibilities and implementation stages. On this basis, the Consultants shall make recommendations as to the best alignment, design and construction standards, right-of-way, and recommend stages of construction, if necessary, for appropriate sections of East-West Rail Link taking into account traffic requirements and the economic viability of its proposed construction work for the corresponding sections.

3) Preliminary Engineering

After review and approval by the Government, the Consultants shall prepare preliminary engineering designs for East-West Rail Link. Preliminary engineering for these studies shall be carried out to a degree of accuracy that will permit estimates of principal quantities of construction with an accuracy of 20 percent. The principal quantities of construction shall include common excavation, rock excavation submaterial, base and surfacing materials, number and size of drainage structures, major bridges, and other structures. Preliminary engineering design of major bridges and other major structures shall include determination of the spans, types of super-structures and types of foundations

including necessary subsurface explorations. Specifications of Phuket New Bridge should be referred to the feasibility study on East-West Road Link.
The Consultants shall undertake all necessary field investigations including necessary soils survey, to determine principal quantities of excavation and construction, prepare the preliminary engineering designs, and locate suitable sources of materials. On the basis of these field surveys, the Consultants shall estimate the construction cost of East-West Rail Link. Unit prices for each item of work shall be broken down into basic cost elements (labor, materials, equipment, tools, taxes, overhead cost and profit). Items for acquisition of right-of-way, physical contingencies, consultant's final engineering fee and supervision fee, and possible escalation of unit costs between feasibility study and final construction shall be provided separately. Purchasing cost of rolling stocks, and operation/management cost should also be estimated.
The Consultants shall identify the components of foreign and local currency for all proposed construction.

The foreign currency component shall include both the direct and indirect foreign currency requirements for the Project. The direct foreign exchange component shall include such items as equipment depreciation, materials and supplies of which Thailand is a net importer, wages of foreign personnel, overhead cost and profit of foreign firms. The indirect foreign exchange component is the import content of locally produced items. The local currency component covers the domestic content of locally produced materials and supplies, local salaries and wages, etc. Provisions for taxes, import duties, etc. will be shown separately. These cost estimates shall be used in a second analysis of East-West Rail Link.

4) Economic Analysis

The economic analysis of East-West Rail Link shall be based on the followings:

(1) Estimates of transport costs on highway and railway;

(2) Estimated costs of railway operation including maintenance on existing and newly constructed sections;

(3) A comparison of the expected economic costs of construction and incremental maintenance and administration costs with the savings estimated in (1) above, for the period of analysis of the East-West Link, for computations of the internal rate of return on the investments;

(4) A sensitivity analysis of the internal rate of return for possible variations in major assumptions made in the estimation of economic costs and benefits;

(5) The identification to the extent possible of unquantifiable economic benefits of the Project and of the anticipated social and environmental impact of the proposed program and an assessment of its importance to the country and the Region influenced by the Project.

Economic justifications shall be provided separately for each alternative alignment.

5) Financial Analysis

Financial analysis should be performed to assess the financial viability of the project as well as to determine the appropriate level of railway fare for self-sustaining and the appropriate distribution of implementation costs to every financial source. It is most important to make clear whether and to what extent the subsidy from the government is to be required for the project. It is also indispensable to discuss the phased development program of East-West Rail Link in full coordination with that of East-West Road Link, particularly from the viewpoint of financial supply.

D. STAFFING

The study team shall consist of experts at least in the following fields;

(1) Project management

(2) Regional economic analysis

(3) Transport planning

(4) Landuse

(5) Railway planning, design and construction

(6) Structural design and construction

(7) Signalling and telecommunication

(8) Train operation and rolling stock planning

(9) Cost estimation

(10) Economic and financial analysis

(11) Material and geotechnical analysis

(12) Hydraulic analysis

3. TERMS OF REFERENCE FOR MASTER PLAN AND SHORT-TERM DEVELOPMENT PLAN STUDIES OF KHANOM DEEP SEAPORT (DRAFT)

A. BACKGROUND

A regional development plan for the upper-southern part of Thailand has already been conceived. The plan is expected to contribute not only to the development of the regional economy but also to the decentralization of industry and population which are presently concentrated in the Bangkok Metropolitan Area and beginning to be concentrated along the Eastern Seaboard.
Surat Thani Area, which will be the major hinterland of Khanom Deep Seaport, is situated in the eastern portion of the Upper-southern Part of Thailand. The area is abundant in natural resources such as agricultural and mining products, some of which are exported abroad and contribute greatly to the regional economy. The export of regional products and import of materials for regional development will increase greatly with the implementation of the above-mentioned plan. Thus, a deep seaport is indispensable for the foreign trade of this subregion.
However, there is presently no deep seaport which can accommodate ocean-going vessels in the area, except an old private gypsum loading jetty at Khanom, and foreign trade commodities are transshipped to other ports outside of the area.

Fortunately, the natural conditions of Khanom, where Khanom Deep Seaport will be located, are suitable for a deep seaport. Khanom also has the advantage of proximity to the international shipping route in the Gulf of Thailand. Furthermore, there is enough land space and water resources for a full-scale industrial development just behind the port, and this is the best advantages of the port. Then, this area is clearly suitable to become an industrial center for the nation.

Therefore, Khanom Deep Seaport is expected to function not only as a foreign trade port, but also as an industrial port in conjunction with waterfront-oriented industry. This industrial development will be planned to start following the Eastern Seaboard Development Program.

When fully developed, Khanom Deep Seaport will contribute greatly both to the regional development of the upper-southern part of Thailand, and to the national industrial development.
The Royal Thai Government is now considering the formulation of a master plan and short-term development plan for the development of Khanom Deep Seaport.

B. OBJECTIVES

The principal purpose of the study is to provide the Royal Thai Government with some recommendations for the future development of Khanom Deep Seaport.
The objectives of the study are:

To prepare a master plan for the development of the port, based on the forecast of developments in the hinterland and prospects of industial development in the study area in connection with the national industrialization and considering the social, economic,

and environmental aspects of port development and the relations between Khanom Deep Seaport and other main ports;

To prepare a short-term plan, including a feasibility study, for the port development.

C. SCOPE OF WORK

In order to accomplish the objectives mentioned above, the study shall cover the following:

1) Field Surveys of Natural Conditions

As no field observations concerning natural conditions at the proposed site have taken place, no precise data are available. Such data are necessary for making the port development plan. The following field surveys should be carried out after reviewing relevant available data which are, however, limited:

(1) Topographic survey

(2) Hydrographic survey

(3) Meteorological observation

(4) Wave observation

(5) Tidal level and current observation

(6) Siltation and survey

(7) Soil investigation

2) Master Plan

The goals of the master plan are:

(1) To study the proper role of the port based on the projections of both social and economic development in its hinterlands, prospects for industrial development in connection with the port, and also its functions and relations to other main ports;

(2) To determine proper functions of the port;

(3) To forecast sea and land traffic through the port with special reference to the target year 2000;

(4) To make a landuse plan for the "direct hinterland", that is for the port area itself and for the area immediately adjacent to it;

(5) To make a basic layout plan of the major port facilities;

(6) To make a basic layout plan of the relevant infrastructures, such as access roads;

(7) To make a rough cost estimate for the plan; and

(8) To technically evaluate the feasibility of port development.

3) Short-term Development Plan

The short-term development plan, including a feasibility study, shall be prepared based on the master plan mentioned above. The target year is to be decided after the completion of the study of the master plan.
The goals of the short-term development plan are:

(1) To forecast traffic demands by sea and land through the port for the target year;

(2) To define the port development plan;

(3) To make a preliminary design of the port facilities;

(4) To make a rough cost estimate and implementation program;

(5) To study economic and financial aspects of the short-term development plan;

(6) To consider the environmental impact of development;

(7) To make recommendations for a sound financing policy for the port, if necessary; and

(8) To make recommendations on the port management system.

Due alternative measures will be proposed if the study leads to the conclusion that the proposed plan is not feasible.

D. STAFFING

The study team shall consist of the experts at least in following fields:

(1) Project management

(2) Industrial development

(3) Economic forecast

(4) Cargo and traffic forecast

(5) Port planning

(6) Urban planning

(7) Structural designing

(8) Construction planning

(9) Port management and operation

(10) Economic analysis

(11) Financial analysis

(12) Natural conditions survey and analysis of oceanographic conditions

(13) Natural conditions survey and analysis of soil conditions

(14) Coordination